Genetic Algorithm Technique to Estimate Yield and Capacity for Proposed Reservoir on Greater Zab River

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Abstract— Iraq will be facing lack in water inflow in Tigris and Euphrates due to construction of dams by neighboring countries on both rivers and its tributaries, in addition to climate changes and its effects on inflow water by decrease in rainfall amount in winter and temperature increase of temperature in summer. The increasing of water needs for population and agriculture extensions will be challenges facing Iraq and all the world for supply and conservation of it. Therefore, it is essential to use modern methods in calculating the water inflow and estimation best distribution in relation to saving cost and time. In this study Genetic Algorithm technique used to expecting outflow from Greater Zab from proposing a reservoir subjected to variable capacity to obtain multi yields to several capacities, number of spill times from spillway and amount of spill after applying of average monthly and yearly inflow for the period of time between 1970 to 2019 (50 years). This technique gives solution which is near optimal solutions. In this study it was obtained variable capacities with multi yields can be use by decision makers and choosing the suitable capacity of reservoir.

Index Terms— Capacity, Genetic Algorithm Technology, Greater Zab river, Optimization technology, reservoir, Tigris River, Yield

1 Introduction

Determining of yield and storge allocation for proposed reservoir on such river is considered the first step toward evaluation of the reservoir to provide the water requirement of the basin.

Genetic Algorithm (GA) is guidance way utilizes to research solutions of problems in endeavor to obtain near optimum solution or solutions. GA has been used to control natural rivers, reviewing the design of constructed dams, reservoirs, Barrages and regulators as well as cutoff site and angle, and scheduling of rivers and canals and other works monitoring the discharges and water levels to obtain a design that is near to optimum. A (GA) depends on development of man to reach optimal solution of design and other using. This GA utilized in many studies around the world. It has been used in several sectors such as scheduling of irrigation canals and open channels (like, Shatt Al Hilla River in Babylon Province in Iraq) to obtain best operation [1][2].

GA model associated with finite element model used to obtain optimum values of inclining angle and cutoff site to water structure of cutoff depth(d)/ floor length (b) ratio. The objective function was to minimize the exit gradient. SEEP2D model utilized to obtain a nonlinear model for calculation head at nodes and the exit gradients (Ge) behind cutoff to give d/b, relative site and inclining angle was called θ. The study showed that the optimal site of cutoff in upstream(U/S) with an angle of inclining between 59° till 68° to d/b = 0.4 or more than 0.4. The optimal site is at the end third of a concrete floor [3]. Other researchers were trying to improve the efficiency of GA wording in GA-TGA optimizing model of the optimal layout in sewer networks design. GA has assured to be effective in terms of optimum solution. GA prove its ability to find an optimum, or near optimum solution. It was doing same as procedure to chromosome evolution of biological development. First operation used primary population randomly after than solution via string of digit each once is named a gene also each set of numbers are symbolized a decision variable named a chromosome. A group of chromosomes are solved [4].

Flexible job-shop of scheduling problem solved by GA. This improving in genetic algorithm first utilizes by hybrid method of random selection with machine assignment. Hybrid way was selected for generating the first population and groups of population. The group utilizes an enhanced genetic operating for global studies, after that best solutions from each group are saved in the elite of library, then the adaptive topical neighbourhood study is utilized in the elite of library for detailed local searches. The simulating experiments are conducted on three groups of international standard samples. The experimental outcomes explain that algorithm is an efficient to disband flexible job-shop scheduling problem [5].

Optimum strategy derived for reservoir operation to help the decision-making in another place, A methodology was suggested includes GA of flow requirements which assumed as restrictions to water exit from reservoir operation when best the ten-day dam storage. GA used to optimize the operational performance of Shih-Men Reservoir of the last 20 years. This way gives very best performance in terms of a small, generalized shortage index (GSI) for demands and greater ecological base flows for most of the years than historical operations do [6].

GA is a tool in studying for the optimum strategy for multi

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utilizes reservoir operations of water resources management. GA model created to find the optimum operation of a multi-purpose reservoir, sited on the stream Pagladia, a big tributary of Brahmaputra River. The policy derived via GA model compares with stochastic dynamic programming model on performance in reservoir simulating for twenty years of river flow. The result explains GA is an effective reservoir operation [7]. The uplift pressure is forecasted accuracy utilizing procedure in various sites [8]. Researchers utilized two types of GA, real and binary coded for function optimization and applying to the optimizing of the flood control reservoirs models. Both GAs is more effective and robust than the random research methods, with real coded GA performing best in terms of efficiency and accuracy than binary coded [9]. Single reservoir operating polices derived by using GA derived, and the researchers mentioned that optimum operation of storage reservoirs, big numbers of simulating and optimizing models have been advanced over the past few decades. The GA has been advanced and used to reservoir to obtain optimum operational strategies. The objective function is minimizing the yearly sum of squared deviation form wanted irrigation release and wanted storage. The decision variables are release for irrigation and demands. GA can be run best if used in exact world operating of reservoirs [10]. GA with finite element used to calculate the optimum cut-off site and inclining angle for barrages built on homogenous anisotropic soil foots [11].

The Japanese company, Electric Power Development Company, (1986) [12] provide Iraqi ministry of water resources through planning report a preliminary design for Bekhme dam, the report shows the storage allocation for the reservoir. The study based on inflow time series of 30 year. Fadhil (1990) [13] submitted reservoir operation scenario for the Bekhme reservoir based on storage allocation determined by this company. the study assumed specified amount of water should be provided by Bekhme reservoir proposed for final stage of development of 2000. The operation scenario shows that Bekhme can satisfied 95% of its share of water to Tigris river Basin.

In this study GA will be applied to calculate the multi yield values with different capacities and estimate spill of dam which was suggested to be constructed on Greeter Zab River. your paper.

2 Experimental Work

2.1 Site and Data of the Study

The study area was Greater Zab River, and its measurement station, Aski Kelek. Greater Zab River that is tributary of Tigris started from Amadiya town of Arbil governorate until Mosul governorate. The study is sited of Latitude from 35º25'00" until 37º20'00"N and longitude from 43º 00'00" until 45º 12'00" E. Swiss Consultants,(1978)[14] used the annual precipitation for the reservoir area for the period 1941-1975 as 920.1 mm, and Selkhopomexport, (1975)[15] considered the annual free-water surface evaporation for the reservoir as 1080 mm. The Fig. 1 explains the research site on Iraqi map and Fig.2 shows the map of study site.

The Greater Zab River feeds by 4 tributaries; Haji Begi, Rawandooz, Shamdinan and Khazir-Gomal. Balikian and Jindian gauging stations are located on Haji Begi and Rawandooz tributaries respectivally and they were not used because both stations have consecutive records for just 15 years and there is not much difference between them and records of Eski-Kelek on the lower part of Greater Zab, Elecric power Development Company ,1986[12]. Manquba gauging station is located on Khazir river, atributary of the Greater zab river, but data of this station was not used since it is located fr away from any proposed dam may be built on main river.

The Greater Zab basin obtains his water by rain, snow, and ground water. The catchment area is 13708 km2 and stretches on lar[illegible] Fig.3 shows

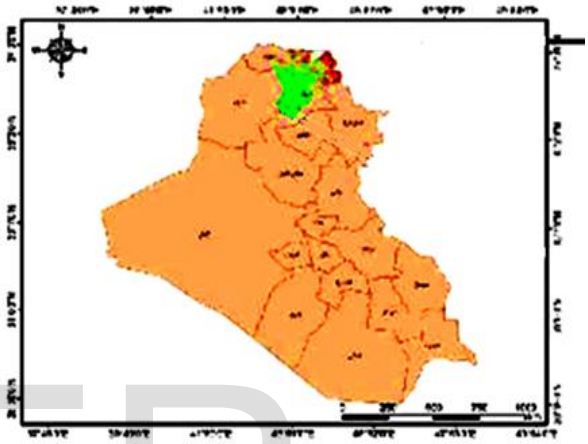

Fig. 1. The research site on Iraqi map.

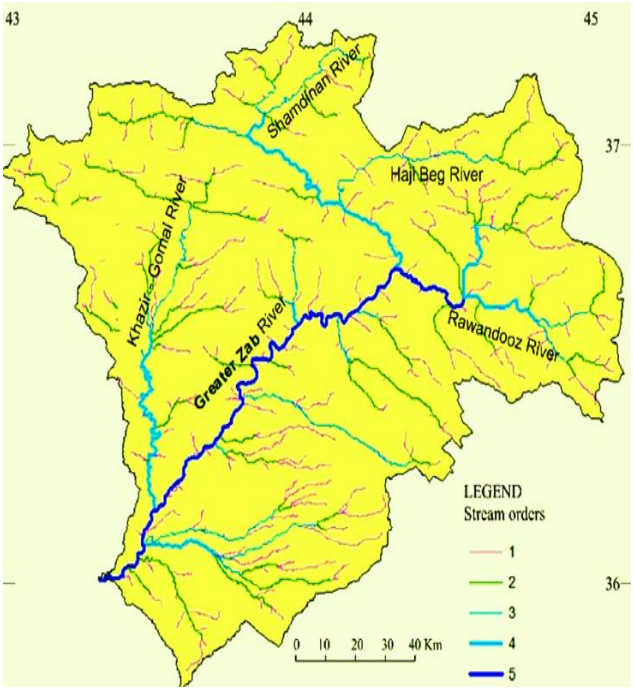

Fig. 2. The map of study site

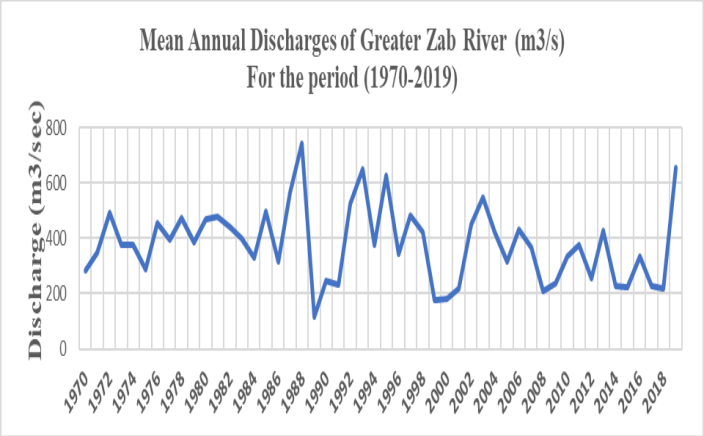

Fig.3. The mean annual discharge for last 50 years.

3 Methodology

3.1 Optimization technology

The optimization technology have multi methods that are used to simplify and facilitate solutions by multi techniques such as linear, nonlinear programs, genetic algorithm(GA), Artificial Neural Network (ANN), colony technique, particle swarm, differential evolution and discrete deferential dynamic program DDDP. These techniques are providing the near optimal solution

Genetic algorithm GA used to determine the optimal reservoir yield and storage for proposed reservoir project on Greater Zab in Iraq.

3.2 Genetic Algorithm

The GA technology was founded by John Holland who utilized principles of development of living organisms which was grown via Charles Darwin .The GA guidance way has been utilized to research for the solution of problems in try for obtaining the optimal solution [16]. GA was used since 1975 to obtain solution to assortment of problems [17]. The GA was doing same as procedure to chromosome evolution of biological development. First operation uses primary population randomly after that solution via string of digit each once is named a gene also each set of numbers are symbolized a decision variable named a chromosome. A group of chromosomes are solving. The GA is doing on some operations which are selecting, crossover and mutation as shown in Fig4.

GA was used to select the fittest strings that will be utilized via the coming generation. Some of approaches were used in GA to select strings and whole are utilized for deciding the probability of selecting as fitness function [18]. Researchers mentioned that crossover operation is used to swap of information between 2 strings of population. The aim of operation is to keep best genes to make powerful chromosomes. The Mutation operator is utilized to avoid genetic algorithm be trapped via local result. Random changing is done of population to avoid likeness in chromosomes. The variation was so small of changing lead to deceleration or stop researching excellent solving [19]. A GA begins researching from several points instead of 1 point as it is worked in traditional Algorithm. Integer values are utilized in GA directly; so, objective functions are not needing to be linear or nonlinear.GA is useful to decision makers to obtain near optimal solution [16]. Fig. 5 show creation of a string of numbers representing all the decisions should be made. Each number is referred to as a "gene". Fig. 6 show Perform crossover with a probability of PC, and Fig.7 show Mutation occurs, replace a randomly chosen bit with a randomly chosen value.

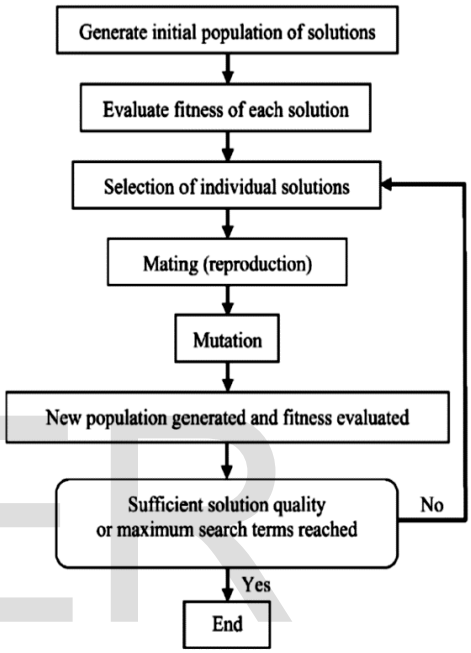

Figure 4. Generalizing framework of a GA [19]

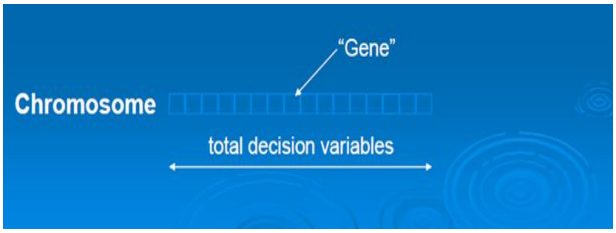

Fig.5. Create a string of numbers representing all the decisions that must be made. Each number is referred to as a "gene" [20].

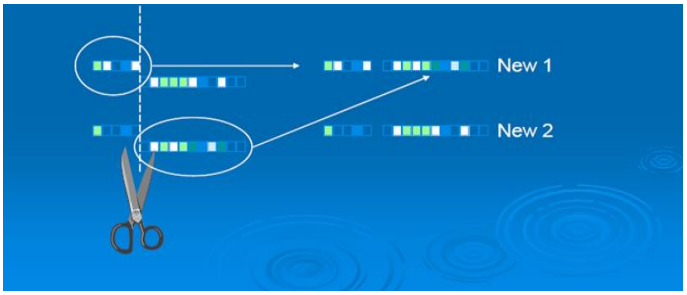

Fig.6 Perform crossover with a probability of PC [20]

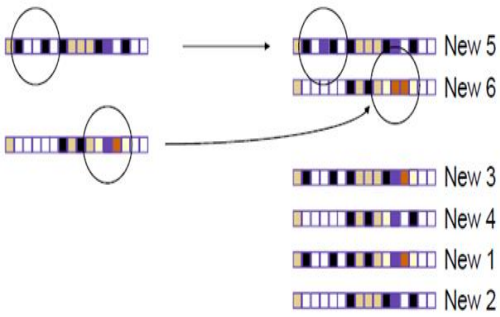

Fig.7 Mutation occurs, replace a randomly chosen bit with a randomly chosen value [21]

4-Model application, result, and discussion

4.1 Model application

The following continuity equation applied in this case study:

Y(i)=S(i)+I(i)-S(i+1)-Sp(i)-ES(i)……1

Where.

Y(i)=yield during ith year; S(i) =initial storage; I(i)= inflow during ith year; S(i+1)=final storage at the end of the ith year; Sp(i)=spill of flooded water at the ith year; ES(i)=Losses through the operation of the reservoir (balance of Evaporation, precipitation and losses through reservoir surface area)

To give estimate for annual losses from the reservoir, the average annual volume of losses due to net amount of evaporation and precipitation should analyses. As mentioned in section (1) Electric Power Development Company, (1986)[12] found the maximum operating storage was 13.670 BCM and minimum operating storage is 4.470 BCM, and average storage will be 9.07 BCM and based on area and storage relationship shown below, Fadhil (1990)[13], the average area will be (155.222) km^2:

AR=-0.0000004514*(S)^2+0.02005*(S)+10.5035 …….. 2

Where AR=Area in Km^2 and (S) is storage in million m^3.

The estimated annual volume for free surface evaporation will be 0.279 BCM, and annual volume of precipitation is 0.142 BCM, based on historical annual depth of 1800 mm of free surface evaporation and 920 mm of rainfall as mentioned in section(2-1).The percentage of annual losses by evaporation will be 3% and 1.5% as precipitation ,while other surface storge assumed to be about 10% ,then total losses assumed 12% of annual storge volume for this study.

Finally, Time series of annual inflow (1970-2019) used to find the optimal Capacity and yield for this proposed reservoir. This GA Algorithm cannot use weights to find optimal operation like nonlinear and goal programming, because the constraints eliminated by upper and lower limits, and this model is single purpose model.

4-2 Results and Discussion

The program of Genetic Algorithm GA as described in section (3-2) run, and result of GA obtained as shown below:

1-GA gave result that of capacity equal 18 billion m3 with yield equal 9.47 Billion m3 and spill for16 times occurred with amount equals 15.3 billion m3 as shown in Table (1).

2-The trial to finding the optimal yield explained by the relationship of capacity with yield of 50 years as shown in Fig. (8).

3-The amount of spill in comparison with yield explained and shown by Fig. (9).

4 -Another trial with total loss from reservoir of 5.5% instead of 12% showed that storage allocation will be 9.9 BCM with storage of 17 BCM. The results shown in Fig (10)

Table 1. The capacity with yield by GA. with capacity of 18 Billion Cubic meter (BCM)and yield of 9.47 Billion cubic meter (BCM) for 50 years

		Capacity (BCM)	18			
		Yield (BCM)	9.47			
		Fitness	-9.47			
Year	Initial Storage at start of year (BCM)	Inflow (BCM)	Yield (BCM)	Evaop -ration + Seepage (BCM)	Spill (BCM)	Difict Storage (BCM)
1970	0.49	23.68	9.47	0.06	0.00	0.00
1971	14.64	8.92	9.47	1.76	0.00	0.00
1972	12.34	11.01	9.47	1.48	0.00	0.00
1973	12.40	15.55	9.47	1.49	0.00	0.00
1974	16.99	11.86	9.47	2.04	0.00	0.00
1975	17.34	11.83	9.47	2.08	0.00	0.00
1976	17.61	9.05	9.47	2.11	0.00	0.00
1977	15.08	14.38	9.47	1.81	0.18	0.00
1978	18.00	12.49	9.47	2.16	0.86	0.00
1979	18.00	14.95	9.47	2.16	3.32	0.00
1980	18.00	12.11	9.47	2.16	0.48	0.00
1981	18.00	14.85	9.47	2.16	3.22	0.00
1982	18.00	15.14	9.47	2.16	3.51	0.00
1983	18.00	13.84	9.47	2.16	2.21	0.00
1984	18.00	12.55	9.47	2.16	0.92	0.00
1985	18.00	10.34	9.47	2.16	0.00	0.00
1986	16.71	15.70	9.47	2.01	2.94	0.00
1987	18.00	9.90	9.47	2.16	0.00	0.00
1988	16.27	17.85	9.47	1.95	4.70	0.00
1989	18.00	23.40	9.47	2.16	11.77	0.00
1990	18.00	3.69	9.47	2.16	0.00	0.00
1991	10.06	7.73	9.47	1.21	0.00	0.00
1992	7.11	7.25	9.47	0.85	0.00	0.00
1993	4.04	16.52	9.47	0.48	0.00	0.00
1994	10.61	20.50	9.47	1.27	2.36	0.00
1995	18.00	11.79	9.47	2.16	0.16	0.00
1996	18.00	19.80	9.47	2.16	8.17	0.00
1997	18.00	10.85	9.47	2.16	0.00	0.00
1998	17.22	15.17	9.47	2.07	2.85	0.00
1999	18.00	13.37	9.47	2.16	1.74	0.00

2000	18.00	5.52	9.47	2.16	0.00	0.00
2001	11.89	5.74	9.47	1.43	0.00	0.00
2002	6.73	6.94	9.47	0.81	0.00	0.00
2003	3.39	14.19	9.47	0.41	0.00	0.00
2004	7.71	17.28	9.47	0.92	0.00	0.00
2005	14.59	13.31	9.47	1.75	0.00	0.00
2006	16.68	9.97	9.47	2.00	0.00	0.00
2007	15.17	13.56	9.47	1.82	0.00	0.00
2008	17.44	11.51	9.47	2.09	0.00	0.00
2009	17.39	6.53	9.47	2.09	0.00	0.00
2010	12.36	7.54	9.47	1.48	0.00	0.00
2011	8.95	10.60	9.47	1.07	0.00	0.00
2012	9.00	11.79	9.47	1.08	0.00	0.00
2013	10.24	8.04	9.47	1.23	0.00	0.00
2014	7.59	13.47	9.47	0.91	0.00	0.00
2015	10.67	7.10	9.47	1.28	0.00	0.00
2016	7.02	10.53	9.47	0.84	0.00	0.00
2017	7.24	7.22	9.47	0.87	0.00	0.00
2018	4.12	6.94	9.47	0.49	0.00	0.00
2019	1.09	9.05	9.47	0.13	0.00	0.00

Penalty factor 100

Average 12.06 BCM Sum=15.30

Deficit storage penalty 0.00

Minimum 3.68 BCM End-Initial storage penalty .000

Sum= 33.42

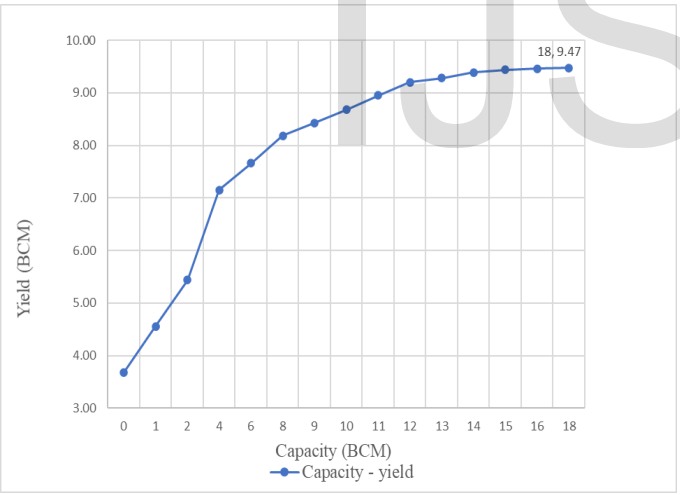

FIG. 8. THE RELATION OF CAPACITY WITH YIELD OF 50 YEARS WITH LOSSES OF 12%.

5-This results looks match with results of determination of storage allocation by The Japanese company, Electric Power Development Company, (1986) [12] or you can see Fadhil (1990)[13]. This company found the the following allocation for Bakhme reservoir:

Maximum reservoir storage 16.990 BCM
Maximum operating storage 13.670 BCM
Minimum operation storage 4.470 BCM
Minimum reservoir storage 1.320 BCM

Although the Maximum storage is 16.990 BCM, but the operating storage is 9.2 BCM, which is near the amount of storage

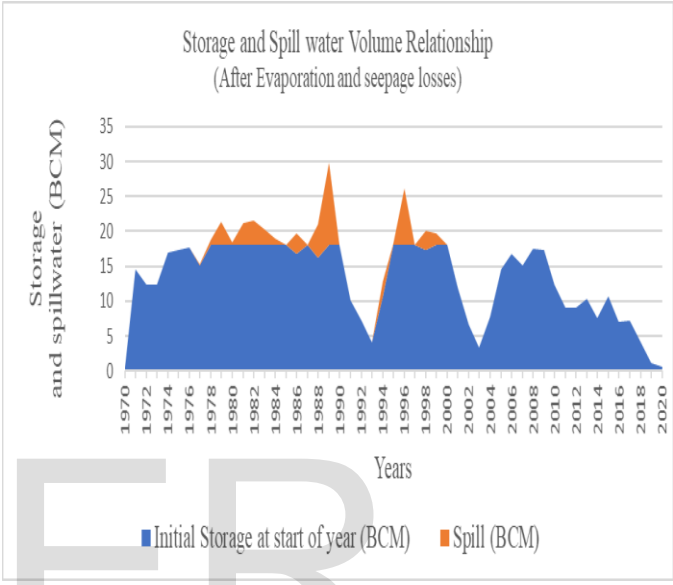

FIG. (9) INITIAL STORAGE AT BEGINNING OF YEARS AND THE SPILL WATER VOLUME WITH STORAGE CAPACITY OF 18 BCM.

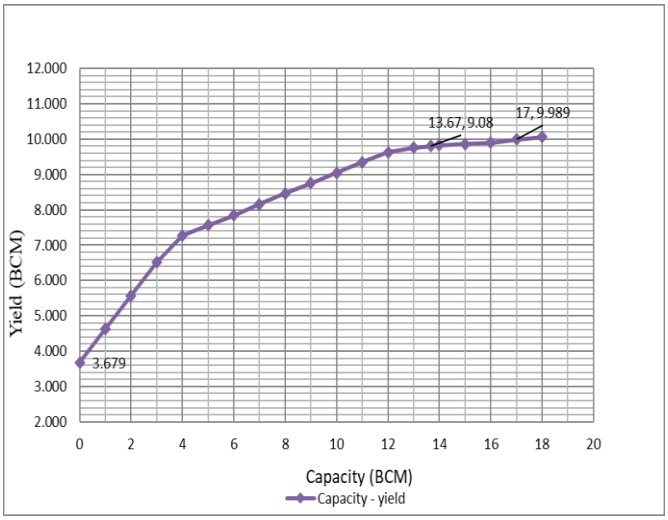

Fig. (10) The relation of capacity with yield of 50 years with losses of 5.5 %.

5-This results looks match with results of determination of storage allocation by The Japanese company, Electric Power

Development Company, (1986) [12] or you can see Fadhil (1990)[13]. This company found the the following allocation for Bakhme reservoir:

Maximum reservoir storage 16.990 BCM
Maximum operating storage 13.670 BCM
Minimum operation storage 4.470 BCM
Minimum reservoir storage 1.320 BCM

Although the Maximum storage is 16.990 BCM, but the operating storage is 9.2 BCM, which is near the amount of storage found by this study.

6-This study compare its results with the this company's results because it doesn't select situation for proposed dam based on the fact that the difference of inflow between the Bekhme dam (north of Greater Zab) and the measurement station on Zab Eski-Kelek (near the end of Zab and its confluence with Tigris River) is about 9% [12]. That is mean any situation is within or less this percentage in difference.

7- The researchers think the storge of 18 BCM and Yield of 9.47 as shown in Table 1, will be reasonable.

5-Conclusion

The GA guidance way has been utilized to research for the solution of problems in try for obtaining the optimal solution. Successful completion of the model is the initial step towards modelling operation and supplying management with additional decision-making tools.

The following conclusions by this study are obtained:

1-Changing of capacity from 0 BCM to 18 BCM, yield from 3.68 BCm to 9.47 BCM obtained through 50 years period and suggested losses of 12%.

2-Another scenario used based on less expectation of losses from reservoir, the results indicated that Capacity with 17 BCM and Yield of 9.9 BCM obtained.

3-Researchers think the first scenario of Capacity of 18 BCM and Yield of 9.47 is reasonable and more match with previous research for this river.

4-Spill of water with changing of capacity from 52.66 to 15.3BCM in case of 50 years.

5-Collection and using more data may be enhance the solution and give more accurate results.

6-There are multi choices for decision makers to select the best capacity depending on capacity and cost.

4 Conclusion

1-The researchers recommend for using Genetic Algorithm and artificial neural network (GA) for further studies dealing with finding storage allocation and yield, other needs for optimal operation, scheduling water and design applications.

2-Using GA technique in calculating the best storage of marshes, as one of important water body in Iraq.

3-Utilizing GA technique to obtain optimal emission uniformity EU in drip and macro sprinkler irrigation systems.

Acknowledgment

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