CHAPTER 07

SUMMARY AND CONCLUSION

The sets of data have been collected and a number of readings and observations have been recorded during the experimental research study on mitigation of evaporation losses from the surface of the reservoirs viz. Vajadi Lake, tank1 and tank2. The results are obtained after the completion of analysis and computational work using various sets of data readings and observations. The glimpses of the findings of the same are given below:

7.1 Findings of the experimental research work carried out on the tanks:

Tank1 and Tank2 are the artificial storage tanks and experiments have been conducted using this artificial storage tanks. The experiment carried out for the two years 2014 and 2015. As both storage tanks were established at same locations the data of temperatures and rainfall remained same. But the surface of tank1 was covered whereas the surface of tank2 was not covered. Hence conclusion of effects of such conditions on the results of the evaporation losses of tank1 and tank2 are important which are discussed below:

7.1.1 Conclusions of the research work based on the experiments undertaken on the tank1 during the year 2014:

(I) The total evaporation losses are found 30 mm in the month of January, 78 mm in the month of February, 92 mm in the month of March, 82 mm in the month of April, 103 mm in the month of May, 100 mm in the month of June, 55 mm in the month of July, 42 mm in the month of August, 42 mm in the month of September, 70 mm in the month of October, 36 mm in the month of November and 32 mm in the month of December respectively.
(II) The total evaporation losses in terms of per cent of volume of the water are found 11.95% in the month of January, 17.46% in the month of February, 24.95 % in the month of March, 29.40% in the month of April, 19.00% in the month of May, 22.61% in the month of June, 14.54% in the month of July, 9.03% in the month of August, 8.70% in the month of September, 15.45% in the month of October, 9.97% in the month of November and 8.95% in the month of December respectively.

(III) The highest evaporation loss in terms of the depth of water is found 103 mm and which is recorded in the month of May and the second highest evaporation loss is found 100 mm in the month of June from the tank1 in the year 2014.

(IV) The highest evaporation loss in terms of the percentage of the volume of water is 29.4 % and it is found in the month of April whereas the second highest is 24.95 in the month of March from the tank1 in the year 2014.

(V) The lowest evaporation in terms of the depth of water is found 30 mm, which is recorded in the month of January, whereas in terms of percentage of the volume of water is 8.70% and it is found in the month of September from the tank1 in the year 2014.

(VI) The monthly mean temperature recorded in the month of May is 30.7°C, in the month of April is 28.2°C, whereas the highest monthly mean temperature during the year 2014 is recorded in the month of June and which is 31.3°C.

(VII) It is observed that from the month of May, the rainfall had started which means the humidity increased and it was recorded 8.09 mm to 185.84 mm from May to July.
(VIII) The total evaporation loss from tank 1 is found 792 mm from the tank 1 during the year 2014.

7.1.2 Conclusions of the research work based on the experiments undertaken on the tank 2 during the year 2014:

(I) The total evaporation losses are found 81 mm in the month of January, 98 mm in the month of February, 96 mm in the month of March, 171 mm in the month of April, 201 mm in the month of May, 226 mm in the month of June, 133 mm in the month of July, 83 mm in the month of August, 90 mm in the month of September, 135 mm in the month of October, 99 mm in the month of November and 71 mm in the month of December respectively.

(II) The total evaporation losses in terms of per cent of the volume of water are found 20.98% in the month of January, 31.31% in the month of February, 44.65% in the month of March, 59.79% in the month of April, 64.84% in the month of May, 77.66% in the month of June, 45.70% in the month of July, 27.67% in the month of August, 26.32% in the month of September, 41.93% in the month of October, 48.06% in the month of November and 33.18% in the month of December respectively.

(III) The highest evaporation loss in terms of the depth of water is 226 mm which is recorded in the month of June and the second highest evaporation loss is 203 mm which is recorded in the month of May from tank 2 during the year 2014.

(IV) The highest evaporation loss in terms of the per cent of the volume of the water is 77.66% recorded in the month of June and the second highest is 64.84% recorded in the month of May from tank 2 during the year 2014.

(V) The lowest evaporation in terms of the depth of water is 71 mm, recorded
in the month of December, whereas in terms of percentage of the volume of water is 20.98% and it is found in the month of January from the tank2 in the year 2014.

(VI) The total evaporation loss is found 1484 mm from tank2 during the year 2014.

(VII) Difference between evaporation losses from tank2 and tank1 in the month of June during the year 2014 is 55.05 % of the volume of water and which is the maximum among all the months. This shows that the maximum volume of water can be saved by covering the surface of storage is 55.05%.

(VIII) The evaporation losses in the month of January from the tank2 and tank1 are 20.98 and 11.95 respectively. The difference between evaporation losses from tank2 and tank1 is 9.03 which is the lowest one among all months during the year 2014.

(IX) The minimum mean temperature during the year 2014 is 16.67°C which is also recorded in the month of January. From this it is concluded that January is the coldest month in the year 2014 and minimum 9.03 % of water can be saved by covering the surface of water in the coldest month of year 2014.

(X) From the results of evaporation losses from the both the tanks and mean depth of the water in the both the tanks of each months of the year 2014 it is concluded that during the hotter months as mean depths of water decrease the evaporation losses increase.

(XI) From the results of year 2014, It is concluded that the evaporation relies on temperature, humidity and depth of water.
7.1.3 Conclusions of the research work based on the experiments undertaken on the tank1 during the year 2015:

(I) The total evaporation losses are found 61 mm in the month of January, 81 mm in the month of February, 126 mm in the month of March, 144 mm in the month of April, 179 mm in the month of May, 204 mm in the month of June, 100 mm in the month of July, 79 mm in the month of August, 98 mm in the month of September, 131 mm in the month of October, 88 mm in the month of November and 56 mm in the month of December respectively.

(II) The total evaporation losses in terms of per cent of the volume of water are found 12.06% in the month of January, 18.32% in the month of February, 27.56% in the month of March, 32.45% in the month of April, 35.39% in the month of May, 24.82% in the month of June, 15.62% in the month of July, 17.76% in the month of August, 18.10% in the month of September, 21.60% in the month of October, 20.69% in the month of November and 12.41% in the month of December respectively.

(III) The highest evaporation loss in terms of the depth of water is 204 mm, recorded in the month of June. The second highest evaporation loss is 179 mm in the month of the May from the tank1 in the year 2015.

(IV) The highest evaporation loss in terms of percentage of the volume of water is 35.39% in the month of May and the second highest is 32.45% in the month of April from the tank1 in the year 2015.

(V) The lowest evaporation loss in terms of the depth of water is 56 mm, recorded in the month of December, whereas in terms of percentage of the volume of water is 12.06% and it is found in the month of January from the tank1 in the year 2015.
(VI) The monthly mean temperature recorded in the month of May is 36.25°C, in the month of April is 33.13°C whereas highest monthly mean temperature during the year 2015 is recorded in the month of June which is 33.41°C.

(VII) It is observed that from month of May the rainfall started, it was recorded 6 mm in May, 448mm in June, 229 mm in July, 10 mm in August and 80 mm in September. It means that the humidity also remained high during this time.

(VIII) The total evaporation loss from the tank1 is found 1347 mm during the year 2015.

7.1.4 Conclusions of the research work based on the experiments undertaken on the tank2 during the year 2015:

(I) The total evaporation losses are found 110 mm in the month of January, 121 mm in the month of February, 215 mm in the month of March, 236 mm in the month of April, 303 mm in the month of May, 314 mm in the month of June, 183 mm in the month of July, 123 mm in the month of August, 135 mm in the month of September, 127 mm in the month of October, 108 mm in the month of November and 79 mm in the month of December respectively.

(II) The total evaporation losses in terms of per cent of the volume of water are found 29.26% in the month of January, 34.97% in the month of February, 59.07% in the month of March, 69.41% in the month of April, 78.70% in the month of May, 65.42% in the month of June, 53.04% in the month of July, 71.51% in the month of August, 54.22 % in the month of September, 54.27% in the month of October, 38.71% in the month of November and 30.98% in the month of December respectively.
(III) The highest evaporation loss in terms of the depth of water is 314 mm recorded in the month of June, and the second highest evaporation loss is 303 in the month of May from the tank2 in the year 2015.

(IV) The highest evaporation loss in terms of percentage of the volume of water is 78.7% recorded in the month of May and the second highest is 71.51% in the month of August from the tank2 during the year 2015.

(V) The lowest evaporation in terms of the depth of water is 79 mm, recorded in the month of December, whereas in terms of percentage of the volume of water is 29.26% and it is found in the month of January from the tank2 in the year 2015.

(VI) The total evaporation is found 2054 mm from the tank2 during the year 2015.

(VII) Difference between evaporation losses from the tank2 and tank1 in the month of August during the year 2015 is 53.75% of the volume of water and which is the maximum among all the month. This shows that the maximum volume of water can be saved by covering the surface of storage is 53.75%.

(VIII) The evaporation losses in the month of February from the tank2 and tank1 are 34.97 and 18.32 respectively. The difference between evaporation losses from the tank2 and tank1 is 16.65 which is the lowest one among all the months during the year 2015. This shows that the minimum 16.65% of the water can be saved by covering the surface of water in the month of February of the year 2015.

(IX) From the results of the year 2015, it is concluded that the speed of vaporization relies on the temperature, the humidity and the dimension normal to the surface of the water.
From the sets of the results of the tank1 and tank2, it is concluded that the evaporation losses remained relatively higher in the months of April, May and June from January 2014 to December 2015.

From the sets of the results of the tank1 and tank2, it is concluded that the evaporation losses remained relatively lower in the months of January and December from January 2014 to December 2015.

7.1.5 Conclusions of the experimental research work undertaken on the Vajadi Lake during the year 2014:

(I) The highest mean temperature is 31.5 °C which is recorded in the month of June at the location of Vajadi Lake. It means June is the hottest month in the year 2014.

(II) The highest seepage loss is 34.96 % recorded in the month of May in the year 2014.

(III) The highest evaporation from Vajadi Lake is 38.95 % found in the month of May when the surface of the lake was not covered. The highest evaporation loss is 22.25% occurred in the month of May when 1000 m² water surface of the lake was covered with the thermocol sheets. This shows that net 16.7% (38.95-22.25) of the water is saved by covering the surface of Vajadi Lake in the month of May in the year 2014.

(IV) 33677.3 m³ quantity of the water is lost due to the evaporation from Vajadi Lake when the surface is not covered during the year 2014.

(V) 18960.62 m³ quantity of the water is lost due to the evaporation from Vajadi Lake during 2014 when the surface is covered with the thermocol sheets.
(VI) Hence, the net 14716.68 m$^3$ quantity of the water is saved by covering the surface of the lake during the 2014.

(VII) The seepage losses are lower in the months of July, August and September. The mean temperatures are not lower during these months whereas the rainfall is higher which results in the increase of the ground water table. It means that the seepage losses depend inversely on the ground water level i.e. higher the ground water level, lower the seepage losses.

(VIII) From January to May the temperatures, the seepage losses and the evaporation losses increase because during this period no rainfall, no runoff, and no ground water are being recharged in the surrounding area.

(IX) 650.9 m$^3$ and 371.8 m$^3$ are the evaporation losses in the month of May when the surface is not covered and the surface is covered respectively. It means 279.1 m$^3$ of the water can be saved by covering the surface of the reservoir. This is the highest quantity of the water saved per month in the year 2014.

7.1.6 Conclusions of the research work based on the experiments undertaken on the Vajadi Lake during the year 2015:

( I ) The highest mean temperature is 34.65° C which is recorded in the month of May at the location of Vajadi Lake. It means month of May is the hottest one in the year 2015.

(II) The highest seepage loss is 36.71 % recorded in the month of April.

(III) The highest Vajadi Lake evaporation is 36.48% found in the month of May when the surface of the lake is not covered. The highest evaporation loss is 23.34% occurred in the month of May when 1000 m$^2$ water surface of the
lake was covered with the thermocol sheets. This shows that net 13.14% (36.48-23.34) of the water is saved by covering the surface of the Vajadi lake in the month of May.

(IV) 35229.4 m$^3$ quantity of the water is lost due to the evaporation from Vajadi lake when the surface is not covered during the year 2015.

(V) 19383.7 m$^3$ quantity of the water is lost due to the evaporation from Vajadi lake during the year 2015 when the surface is covered with the light weight blocks.

(VI) Hence, net 15845.7 m$^3$ volume of the water is saved by covering the surface of the lake during the year 2015.

(VII) The seepage losses are lower in the month of June, July, August and September. The mean temperatures are not lower during these months whereas the rainfall is higher which results in the increase of the ground water table. It means that the seepage losses depend inversely on the ground water level i.e. higher the ground water level, lower the seepage losses.

(VIII) From January to May the temperature, the seepage losses and the evaporation losses increase because during this period no rainfall, no run off, and no ground water are being recharged in the surrounding area.

7.2 Summary of the research:

The water is the most essential, prime and crucial requirement of all the living organisms. Our country is an agrarian country and the water is the prime need to increase the yield of agricultural products. Our country receives and preserves the water in forms of the rainfall, the snowfall and groundwater. However, the quantity of the water is not in our control. There are always losses of
the water in the system of the water storage and the supply. The water losses evaporation is one of the major losses of the water from the storage of the water.

The estimation of the amount of the water evaporated is required for the purpose of the planning and operation of various irrigation and the water resources schemes. The estimation of water evaporated and subsequent measures to be taken to control the evaporation are extremely important in the arid regions such as the regions of Rajasthan and Gujarat where the sources of water are limited and scarcity of water is a common phenomenon.

Hence, in order to resolve the problem, in the present research work of mitigation of the evaporation on the bodies of water has been undertaken. The research consists of the estimation and reduction of evaporation losses. The mitigation of evaporation is carried out by using the thermocol sheets as the surface covering material for the duration of one year i.e. 2014 on one hand. On the other hand the surface is covered with the use of the light weight blocks as the surface covering materials for the period of one year i.e. 2015. At the end of the research, it is found that the net 14716.68 m$^3$ quantity of the water is saved by covering the surface by using the thermocol sheets during the year 2014 and the net 15845.7 m$^3$ volume of the water is saved by covering the surface by using the light weight blocks during the year 2015.

7.2.1 Limitations and recommendations of the present study:

The effects of each and every parameter which affects the results of estimations of evaporation losses and results of quantity of water saved are taken into account in the present research. The care is also taken during the research that there is no chance of any type due to the errors occurring through improper materials, faulty instruments, less perfect methods, insufficient information, personal error or human limitation. Nevertheless, the following few limitations are noted during the present study.

(I) Limitations of the present study:
1. The atmospheric pressure and water vapour pressure are not observed during the study at both the locations of the experimental research.

2. The humidity is neither recorded nor taken into the mathematical formula to calculate the evaporation losses.

3. The seepage losses are measured but not on continuous bases which occur continuously from the Vajadi Lake.

4. The size, depth and numbers of holes or pipes dug by burrowing animals such as mice and snacks in the bottom of the Vajadi lake are not observed and hence the effects of holes or pipes on the rate of seepage is also not computed.

5. The potable water is used in the artificial tanks but quality of the water during the research work is not monitored on the continuous bases. During the evaporation process only water is evaporated but the total dissolved solids are not evaporated and hence the concentrations of dissolved solids are increased.

6. The quantity of water consumed from the Vajadi Lake by the cattle such as buffalos, goats and cows are considered but used by the dogs and cats are not taken into account.

7. The thermocol sheets which are used as surface covering materials are arranged in such a manner that aquatic lives were not disturbed but long term effect of the sheets as covering material on the aquatic life are not observed.

8. It is very well known that there is no reaction between the water and thermocol sheets but effects of the water and weather on the long term durability of the thermocol sheets are not observed.
9. Autoclaved Aerated Concrete (AAC) blocks are also used in the present study as surface covering materials in the year 2015 but the impacts of the AAC blocks on the environment and on the aquatic lives are also not observed.

10. The long term durability of AAC blocks are not measured in the present study.

11. The cost comparison and cost benefits analysis between two surface covering materials i.e thermocol sheets and AAC blocks are not carried out in the study.

On the bases of the limitations and observations, following are the recommendations which may be very useful.

1. The weather parameters such as atmospheric pressure, water vapour pressure, humidity etc should be observed during the research on the continuous bases and effects of the same should be considered in the mathematical calculations and methods.

2. Mathematical model should be established and designed so it is very useful for applying or using the outcomes of the present study into other works or different study area of same nature as that of the present study area.

3. For obtaining better and more reliable readings of the seepage losses instrument should be designed and calibrated so on the continuous bases seepage losses can be recorded.

4. One should continuously monitor the quality of the water and then find its effects on the rate of evaporation and should try to find the relations between the quality of the water and the rate of the evaporation losses.

5. The temperature of the water near the surface covering materials should be observed on the continuous bases and established the relations between the temperatures of the water where the surface is covered, temperature of the water where surface is not covered and temperature of the atmosphere.
6. The shape and size of the shadow of the surface covering materials (thermocol sheets and AAC blocks) should be observed and at the same time effects of the shadows on the temperature of the water should be observed so that the rate of the evaporation can be investigated.

7.3 Scope of the future work:

The mitigation of evaporation from the surface of reservoirs is a very wide area of research. During the current research the thermocol sheets and the light weight aerated blocks are used for covering the water surface of the reservoir. One can conduct further research on the following areas:

1. One can investigate the long term impacts of the thermocol sheets and AAC blocks on the aquatic lives and on the environment.

2. The long term durability of the materials thermocol and AAC can be determined and for that long term research study can be conducted.

3. One should investigate the effects of the sizes and shapes of thermocol sheets and AAC blocks on the rate of the evaporations by conducting experimental research using different shapes and size of the thermocol and AAC.

4. Further investigation can be carried out by using some other materials, other than the thermocol and AAC, for covering the water surface in order to reduce the evaporation losses.

7.3.1 Use of the solar panel as a surface covering materials

The solar panels have been used over the water surface of the canal in the state of Gujarat. The Electricity Board of Gujarat State has established a solar power plant over 3600 meters length of the canal of the Sardar Sarovar Canal System. After the success of the solar power plant over the
surface of the canal water in Gujarat, the state of Haryana also plans the similar solar power plant on the top of a canal. However, there are a few areas of research that can be explored henceforth.

- One can initiate a new research study on a similar type of solar power plant for availing the specific quantity of clean and renewable energies that can be measured for finding quantity of the water that can be saved at the same time.

- One can also undertake a research of covering the water surface of reservoir by the floating solar panels.

- One can also undertake a research of covering the water surface of reservoir by the floating ball on which solar cell is printed.

- One can also carry out the detailed analysis of the cost benefits ratio when the surface is covered with the solar panels.

- One can also conduct the detail investigation to find the effects of the solar panels on the temperatures of the water when floating solar panel is used as surface covering materials and the effects of the water on the temperatures of the solar cell and hence on the efficiency of the solar cell.

- One can conduct the investigation to compare the amount of electrical energy generation when solar panels float on the water and solar panel lay on the terrace of a building. In this comparison the cost of the land considered in the case of solar panel lay on the land and not included in case of the floating solar panel as land is not needed.

- One can also conduct the investigation as to how much carbon credits can be earned when solar panel is used as there is no air pollution involved in the process and there is no greenhouse gases including carbon dioxide produced and emitted in the atmosphere during the generation of the solar energy.