JICHE 2014 Technical Program			
	Tuesday 04 Nov. 2014		
09:00 – 17:00	Registration(**Landmark Amman Hotel**)		
10:00 – 10:30	Inauguration		
10:30 – 11:00	Welcome and Coffee Break		
11:00 – 12:00	***Keynote Lecture 1*** **Graphene-Polymer Nanocomposites for Enhancing Energy and Water Production** ***Prof. Vincent Gomes***		
12:00 – 13:00	***Keynote Lecture 2*** **Simultaneously Strong and Tough Continuous Nanofibers for Structural and Functional Materials and Composites** ***Prof. Yuris Dzenis***		
13:00 – 13:30	***Coffee Break***		
13:30 – 14:30	***Session 1: Chemical Reaction Engineering I***	***Session 2: Nanotechnology***	***Poster Presentations***
14:30 – 15:30	***Session 3: Chemical Reaction Engineering II***	***Session 4: Other Chemical Engineering Processes I***	
15:30 – 16:30	***Lunch***		
16:30 – 20:00	***Workshop 1: Nanotechnology: Incorporation in Industry***		
	Wednesday 05 Nov. 2014		
09:00 – 17:00	Registration(**Landmark Amman Hotel**)		
09:00-10:20	***Session 5: Energy I***	***Session 6: Water and Environment I***	
10:20-10:40	***Coffee Break***		
10:40-11:40	***Keynote Lecture 3*** **The roles of government and industry in oil shale development** ***Prof. Jim Schmidt***		
11:40-12:40	***Keynote Lecture 4*** **Catalysis and Energy** ***Prof. David Rooney***		
12:40-13:10	***Coffee Break***		
13:10-14:10	***Keynote Lecture 5*** **Advanced Oxidation Processes for Water Treatment – Needs and Prospects for Large Scale Applications** ***Prof. Anastasios J. Karabelas***		
14:10-15:30	***Session 7: Energy II***	***Session 8: Water and Environment II***	
15:30-16:30	***Lunch***		
16:30-20:00	***Workshop 2: Processing and utilization of oil shale***		
	Thursday 06 Nov. 2014		
10:00-11:00	Registration(**Landmark Amman Hotel**)		
10:00-11:20	***Session 9: Energy III***	***Session 10: Separation I***	
11:20-12:00	***Coffee Break***		
12:00-13:00	***Keynote Lecture 6*** **Sustainability of RO desalination in meeting future water demands** ***Prof. Hassan Arafat***		
13:00-14:20	***Session 11: Other Chemical Engineering Processes II***	***Session 12: Separation II***	
14:20-15:00	***Closing Sessions***		
15:00-16:00	***Lunch***		

(Petra) Hall **(Rum I) Hall** **(Rum II) Hall**

Wednesday 05 Nov. 2014

	Time :09:00-10:20 ***Session 5: Energy I*** ***Chair: Prof. Mohammad Matouq*** ***Co-Chair: Dr. Ibrahem Altarawneh***		***Time :09:00-10:20*** ***Session 6: Water and Environment I*** ***Chair: Prof. Omar Alayed*** ***Co-Chair: Eng. Ruwida Zomot***
1	Formulation of a Single Char Particle Model for Naphthalene Removal in Biomass Gasification *Z. Abu El-Rub, G. Brem, E.A. Bramer*	**1**	Assessment of Rainwater Harvesting Potential in Jordan *Pramod K Pandey*
2	Shell and Double Concentric Tube Heat Exchanger calculations and Analysis *Basma A. Abdulmajeed Fadhil AbedAllawi*	**2**	Performance Enhancing of Blended Ionic Liquids as Demulsifiers for Water in Oil Emulsions *Sawsan A.M. Mohammed, Watheq Kareem Salih*
3	Activation of Oxygen for Partial Oxidation of Methane with the Fuel Cell Type Reactor Using $LaGao_3$ Membrane *Tomohiko Tagawa, Yoshinori Terao, Yasushi Miyata, Hiroshi Yamada, Makoto Inomataa*	**3**	Water Defluoridation by Calcined Gypsum: Influence of Additives *Areej A. Al-Bedoor, Aiman Eid Al-Rawajfeh, Da'san M. M. Jaradat, Yara Al-Jaradeen, Ala'a Al-Obeidein*
4	New Processes for the Treatment of the used Alkaline Solutions from Merox and Exomer Plant *Florin Oprea, Elena-Fendu Mirela, Marilena Nicolae, Octav Pântea*	**4**	

10:20 – 10:40 | ***Coffee Break***

Keynote Lecture3 — ***Time :10:40-11:40*** — ***Chair: Prof. Omar Alayed***
The roles of government and industry in oil shale development
Prof. Jim Schmidt, PROCOM Consultant, Australia

Keynote Lecture4 — ***Time :11:40-12:40*** — ***Chair: Prof. Omar Alayed***
Catalysis and Energy
Prof. David Rooney, Director for CenTACat, UK

12:40 – 13:10 | ***Coffee Break***

Keynote Lecture5 — ***Time :13:10-14:10*** — ***Chair: Dr. Ziad Abu El-Rub***
Advanced Oxidation Processes for Water Treatment – Needs and Prospects for Large Scale Applications
Prof. Anastasios J. Karabelas, Laboratory of Natural Resources and Renewable Energie, Greece

	Time :14:10-15:30 ***Session 7: Energy II*** ***Chair: Dr. Rand Abu Zrieq*** ***Co-Chair: Eng. Ruwida Zomot***		***Time :14:10-15:30*** ***Session 8: Water and Environment II*** ***Chair: Prof. Fahmi Abu-Rub*** ***Co-Chair: Prof. Omar Alayed***
1	The Pinch Method Applied to Preheat the Crude Oil After Desalting *Negoita Loredana, Popa Maria*	**1**	A Novel Method for Electrochemical Removal of Cadmium from Simulated Waste-Water by Using Stainless Steel Mesh Concentric Tubes Cathode *Abbas Hamid Sulaymon, Basma A. Abdulmajeed, Anas B. Salman*
2	The Environmental Performance of Future Power Generation Scenarios in Jordan *Ali El Hanandeh*	**2**	New Agricultural Waste Adsorbent for the Removal of Phenol and 4-Nitro Phenol from Aqueous Solutions *Maha Al-Hassani, Nada S. Ahmedzeki, Haider Al-jendeel*
3	Predictive Control of A Solar Power Plant *N.djouamaa, M.L.Saidi, S.Kermiche*	**3**	Spatial Variability of Physico-Chemical Properties of Shallow Aquifers Water in Arid Desert Region *Mohamed Djidel, Sofiane Labar, Fethi Medjani, Samir Djorfi*
4	The Investigation of Production of Biodiesel From Poultry Fats as an Alternative Fuel Than Traditional Petroleum Diesel Fuel *Ribwar K. Abdulrahman*	**4**	Softening of Brines by Auto-Regeneration (AR) of Composite Materials *Aiman Eid Al-Rawajfeh*

15:30 – 16:30 | ***Lunch***

16:30-20:00 | ***Workshop 2: Processing and utilization of oil shale***

(Petra) Hall **(Rum I) Hall** **(Rum II) Hall**

ASSESSMENT OF RAINWATER HARVESTING POTENTIAL IN JORDAN

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ABSTRACT

Considering the dwindling supply of water, rainwater harvesting in many of countries of South East Asia, can be a viable option. Here we exploited a model for assessing the rainwater harvesting potential in Jordan. Model predicted water storages in rainwater harvesting tank receiving water from impervious surfaces. In order to predict stored water, we used rainfall, and evaporation data. Runoff from catchment was channeled to water storage tank for conserving rainwater. Under variable scenarios i.e., impervious catchment, pervious catchment, evaporation, and non-evaporation conditions, water storages in rainwater harvesting tanks was predicted. Results showed that both seepage and evaporation can diminish the water storage in reservoir considerably. However, when reservoir was lined, and catchment was considered impervious, the water storage increased. Further, when evaporation was controlled, water storage in the reservoirs increased significantly. We anticipate the results, and model presented here will support improving rainwater strategies in Jordan.

Keywords: rainwater harvesting, model, water resources

INTRODUCTION

Enhancing gap between water supply and demand is a serious concern, which requires urgent attention to alleviate water shortages. A recent human development report by United Nations emphasizes the water crisis at global scale (United Nations, 2010). A study by Falkenmark and Rockström estimated that by 2050 more than 59% of the world population will be living in areas with limited water availability (Falkenmark and Rockström, 2006; Rockström et al., 2009). Barlow (1999) estimated that if current trends of water demand persist then by 2025 the demand of fresh water will most likely rise by 56% more than the existing available water.

While water crisis is not limited to only developing countries, the impacts of water shortage on the livelihood of people in developing countries will likely to be greater than the developed countries because of excessive dependence on agriculture. As an example, more than 70% of people in India live in rural area (mainly dependence on agriculture); 47% of GDP of Ethiopia comes from agriculture. Currently approximately 75% of the world's total water consumption is for agriculture. Ongoing trends of improvement in living standard and water demand for urban regions in many developing countries will likely to put stress on water supply that will influence the water availability for agriculture.

Many of dry and semi-dry regions of Asia are facing acute shortage of water. For example, the largest environmental challenge of Jordan is the scarcity of water (Abdulla and Al-Shareef, 2008). Current water use is greater than renewable water supply. Climate condition (i.e., elevated solar radiation and aridity) is the governing factor of water resources in Jordan.

In order to meet future water demand for agriculture and urban regions, sustainable water resources, and conservation of existing water are crucial. Rain water harvesting can be a viable option for enhancing the water resources in Jordan (Abdulla and Al-Shareef, 2008). While assessing the residential rainwater harvesting efficient in Jordan, Mehrabadi et al. (2013) calculated that residential building's roof with rainwater harvesting facilities can meet 70 – 75% of non-potable water demand, depending on the climate conditions. Abdulla and Al-Shareef (2008), who studied rainwater harvesting potential in residential sectors of 12 Jordanian governorates, estimated that 15.5 Mm^3/y of rainwater can be collected from roofs of residential buildings, which is equivalent to 5.6% of total domestic water supply. Considering the importance of rainwater harvesting potential in Jordan, here a modelling study was carried out to assess the rainwater harvesting potential from impervious surfaces. The objective was to enhance the understanding of rainwater harvesting potential in Jordan under various seepage and evaporation conditions.

Methods

To understand the rainwater harvesting potential from an impervious surface, a recently model published by Pandey et al. (2013) was modified. Conceptual model is shown in Figure 1. The reader are encouraged to ready studies by Pandey et al. (2011) and Pandey et al. (2013) to understand the model details. In brief, the original model, which was developed for predicting the rainwater harvesting potential in agriculture land, was transformed into a model capable of predicting water storages from impervious surface (no seepage). Harvested rainwater was stored in tanks with the

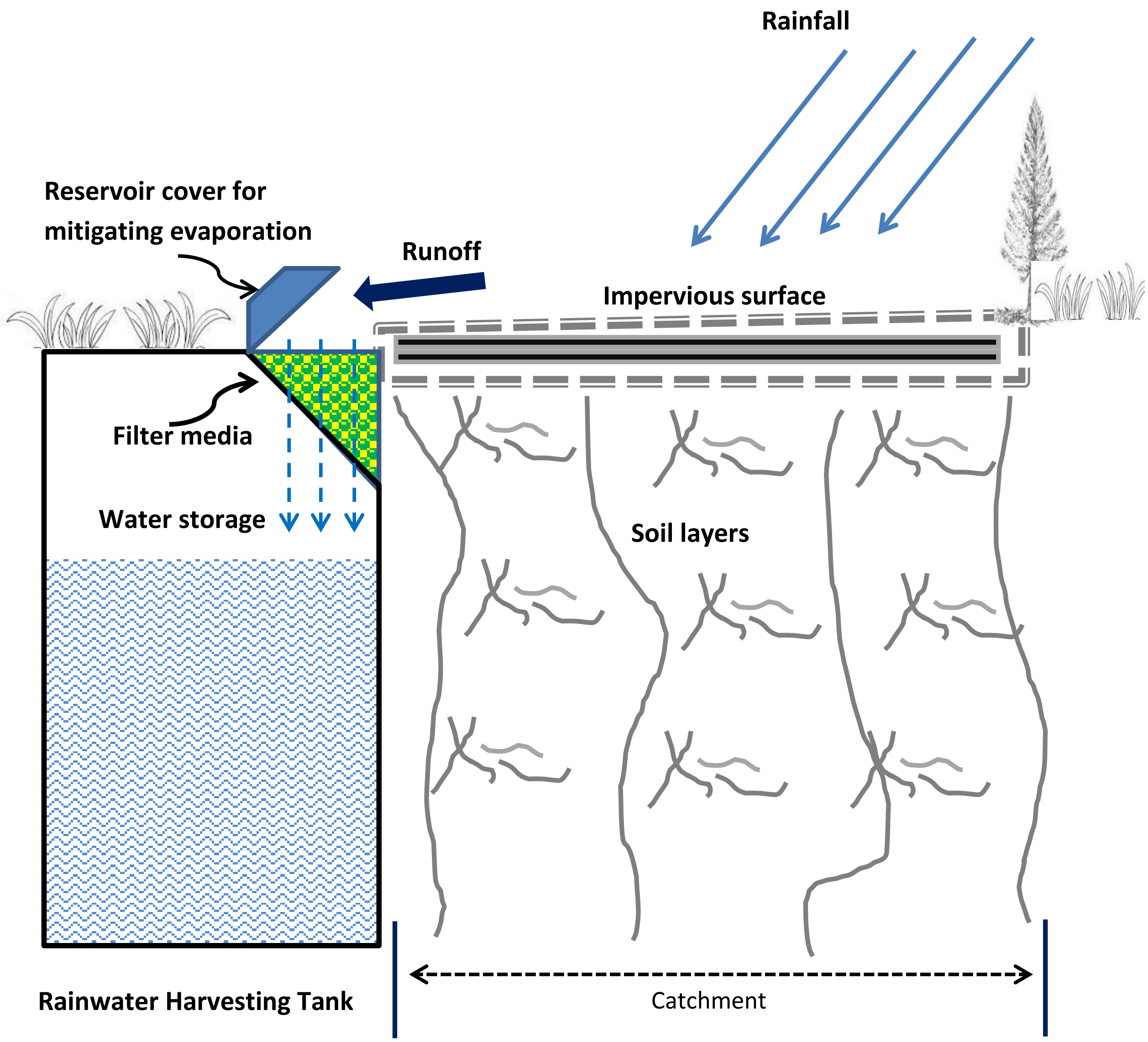

Fig. 1. Conceptual model for rainwater harvesting from impervious soils to seepage and evaporation proof rainwater harvesting tank.

capability of preventing seepage and evaporation losses. As shown in Figure, runoff from impervious layers was estimated, and it was stored in an adjacent rainwater harvesting tank. The lining of the tank controlled the seepage losses, and top covering prevented evaporation losses. Model was used to estimate rainwater storages in three scenarios: 1) no seepage and evaporation; 2) minimal seepage and no evaporation; and 3) minimal seepage and evaporation. A scenario analysis provided insight how seepage and evaporation losses can potentially influence water storages in rainwater harvesting tank. Location of study is shown in Figure. 2.

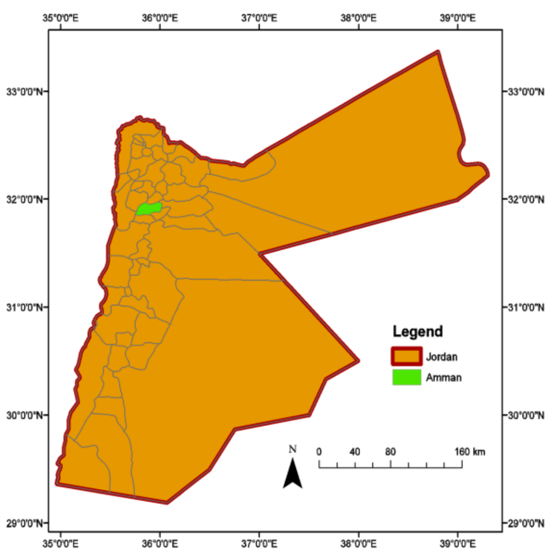

Fig. 2. Location map of study area

Simulation and input data

In order to simulate the rainwater storages in rainwater harvesting tank, the three climate parameters (temperature, rainfall, and evaporation) were used as input. In the absence of daily rainfall, temperature, we used monthly available data for estimating daily values. Monthly data was interpolated to calculate the daily data. Monthly data of rainfall and temperature, available from Climate Change Knowledge Portal of World Bank Group (World Bank Group, 2014) was used to estimate daily data. Evaporation data of Amman, Jordan was retrieved from UN Data portal (UN Data, 2014).The estimation of daily temperature, rainfall, and evaporation is shown in Figure 3. Developing a single polynomial regression trend line to calculate daily values was not successful. The interpolated data were overestimation compared to the observed data. Therefore, we developed two regression equations for each parameter (shown in Figure 3). Polynomial regression equation for rising and falling limb was estimated separately. Similar approach we adopted for all input estimation (i.e., temperature, precipitation, and evaporation). Subsequently the estimation of rising limb was combined with the falling limb, and a dataset of 365 Julian days was estimated.

Simulation was performed for a year (365 Julian Days) using rainfall, temperature, and evaporation data. The size of impervious surface was taken as 10 ha. 10% of the impervious surface area was considered as the reservoir (shown in Figure 1) area. The depth of reservoir was set to 3 m (with rectangular shape), which resulted the volume of reservoir of 30,000 m^3.

For estimating the runoff from impervious surface, CN of 98 (for impervious surface) was used. Initial water storage was considered to be 15% of reservoir volume. We used 15% of precipitation as interception storage. Model constant and additional input parameters are described elsewhere (Pandey et al., 2013). While simulating the rainwater storages in the reservoir, firstly we considered that rainwater harvesting tank as well as impervious is seepage proof (i.e., no seepage losses). In addition, we assumed that water losses from the evaporation were controlled (no evaporation losses from rainwater harvesting tank) by covering the top of the reservoir (Figure 1). Secondly, we simulated the water storages, where the impervious layer as well as rainwater harvesting tank was subjected to a minimal seepage but no evaporation. A seepage rate of 0.15 cm/hr was used to estimate the seepage losses, which corresponds to 45% of the hydraulic conductivity of loam soils. Thirdly, we estimated rainwater storages when both seepage and evaporation were active. A evaporation rate of 1.1 mm/day, which is about 15% of seepage rate of study area (Amman). For this region, annual evaporation is about 2562 mm with 7 mm/day. Subsequently, the rainwater storages under above three conditions was predicted.

Results and Discussion

Figure 3 shows the results of interpolation of daily temperature, rainfall, and evaporation data. The daily observed temperature varied from 8.8 to 28.3 ^{0}C with mean of 19.2 ± 7.3 ^{0}C. As shown in the Figure 3A, polynomial equations were developed for calculating the temperature profile of rising and falling limb. R^2 value for rising limb was 0.99, and for falling limb, it was 0.98. Subsequently, the calculations of rising and falling limbs were combined, and compared with observed data (shown in Figure 3B). Results showed a well alignment between predicted and observed daily values (Figure 3B).

Similar to temperature, daily rainfall pattern was estimated using the monthly data shown in Figure 3C. The cumulative annual rainfall was 93.2 mm. Majority of the rainfall concentrates between December and March, which is about 75% of the total annual rainfall. As shown in Figure 3C, daily rainfall was estimated using the interpolation of rising and falling limbs. R^2 value for rising limb was 1, and R^2 value for falling limb was 0.95. Subsequently, rising and falling limb data was combined to obtain daily rainfall data of a year, which is shown in Figure 3D. Results showed well alignment between observed and estimated value of daily rainfall (Figure 3D).

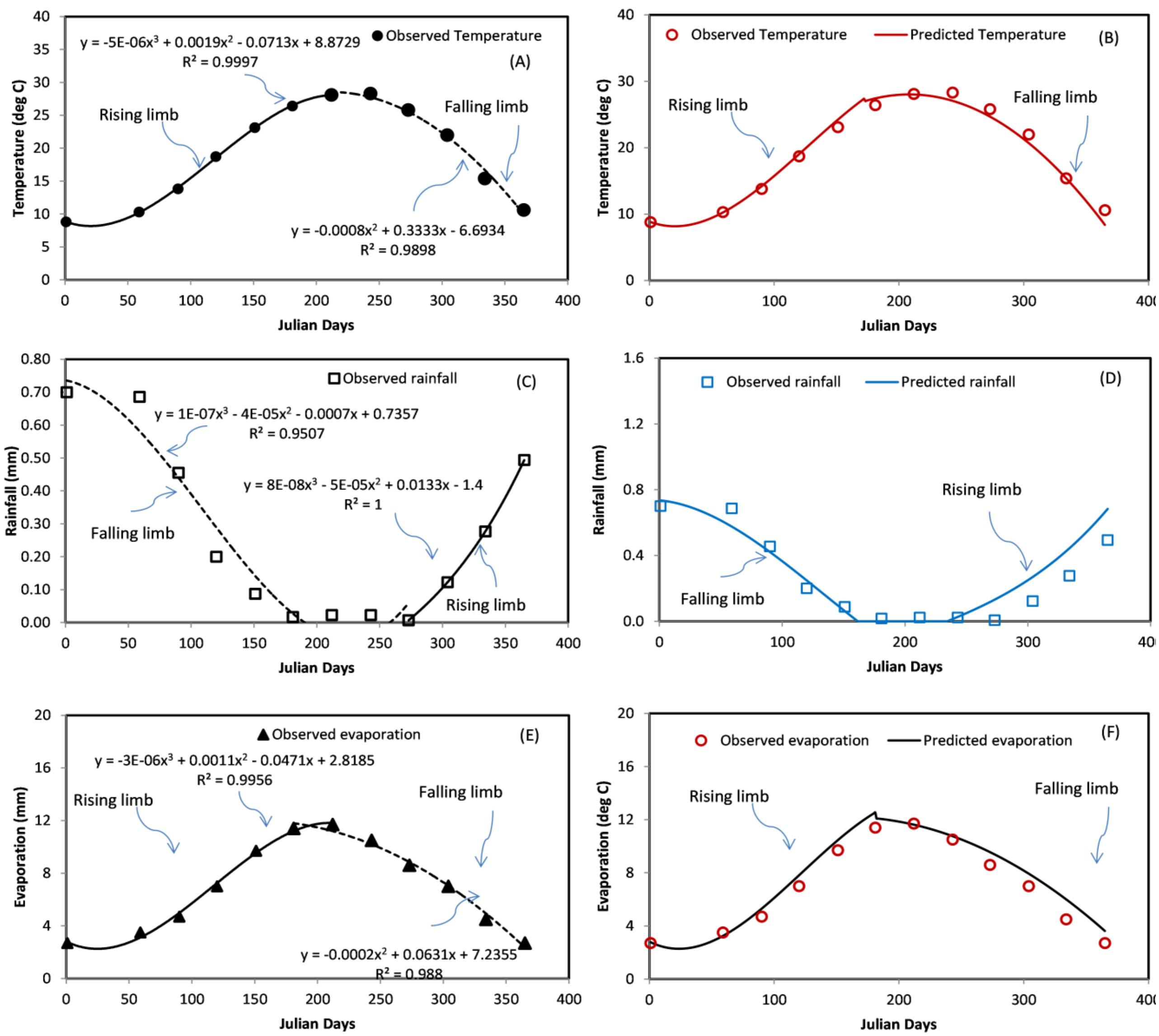

Fig. 3. Estimation of daily temperature, rainfall, and evaporation from monthly observations

Evaporation data is shown in Figures 3E and 3F. Similar to temperature and rainfall data, a separate interpolation was performed for rising and falling limbs of observed evaporation. Mean daily evaporation varies from 2.7 mm to 11.7. Total annual evaporation was around 2562 mm. Majority of the evaporation occurs between May to September with the highest in June – July. While interpolation the evaporation R^2 value for rising limb was 0.99, and for falling limb it was 0.98. Comparison between estimated and observed daily value is shown in the Figure 3F. Total annual observed evaporation was 2562 mm, while calculated observed value was 2763 mm (93% of the observed values). Results showed predicted and observed daily values were comparable (Figure 3F).

Daily data shown in Figure 3 were used to calculate the rainwater harvesting potential shown under various scenarios, which is shown in Figure 4.In the first scenario (Figure 4A), when reservoir and impervious layer were complete seepage proof, and no evaporation losses occurred from reservoir, the rainwater storages varied from 4557 m^3 to 11,883 m^3. Average water storage in the reservoir was 9,110 m^3. (± 1515 m^3).

In the second scenario, when reservoir and catchment was subjected to seepage, the water storage was lower. The water storages under saturated hydraulic conductivity of 0.15 cm/hr is shown in Figure 4B. Water storages varied from 3721 m^3 to 6,870 m^3. The average water storage was 5094 m3 (± 1260 m^3).

Water storages in the third scenario is shown in Figure 4C. The minimum storage in the third scenario was 0 m^3, when seepage was 0.15 cm/hr, and daily evaporation was 1.1 mm/day, which is about 15% of the actual daily evaporation in Amman (7.0 mm/day). The maximum storage was 5842 m^3. The mean storage was 3190 m^3 with deviation of ± 2194 m^3.

Comparing the results shown for three scenario, results clearly indicate that seepage and evaporation will most likely to be crucial controlling factors in Jordan for enhancing the water storages in rainwater harvesting tank. In the current, scenario analysis, we used minimal seepage and evaporation values. As an example in first scenario, we used saturated hydraulic conductive of 0.15 cm/hr which is only 15% of the saturated hydraulic conductivity of loam soil. Similarly, evaporation rate was minimal i.e., 15% of the actual evaporation in Amman.

Results indicate that minimum storage in second scenario was about 72% of the first scenario. Maximum scenario was about 58% of the first scenario. The mean storage was about 59% of the mean storage of the first scenario. Standard deviation was about 83% of that of the first scenario.

In third scenario, maximum storage was 35% of that of the first scenario. Mean storage was 35% of the mean storage of the first scenario. Deviation in storage was larger in the third scenario compared to the first scenario (deviation of first scenario was 69% of the third scenario).

Comparison between second and third scenario indicated that maximum storage in the third scenario was 85% of the second scenario, and mean storage of third scenario was 63% of the second scenario. The deviation of second scenario (standard deviation) was 57% of the third scenario.

Results of this study clearly indicated that rainwater harvesting potential (i.e., storages) in Jordan will mainly depends on seepage and evaporation. Identifying the design of rainwater storage structure capable of mitigating seepage and evaporation will be crucial for adopting rainwater harvesting at a large scale. Such water storage structures must be cost effective in order to disseminate and propose to the people interested in conserving the rainwater.

In summary, this study showed that harvesting runoff from impervious surface of Jordan can be an option for enhancing the water resources in Jordan. Rainwater storage will vary depending on the water storage structures. Due to high evaporation rate in Jordan, approaches to mitigate evaporation will be crucial for enhancing the water volume in water storage structures. Similarly, lined reservoir i.e., reservoir with no seepage will potentially enhance the water storages. We anticipate that the preliminary study and scenario analysis presented here will help improving rainwater harvesting system in Jordan.

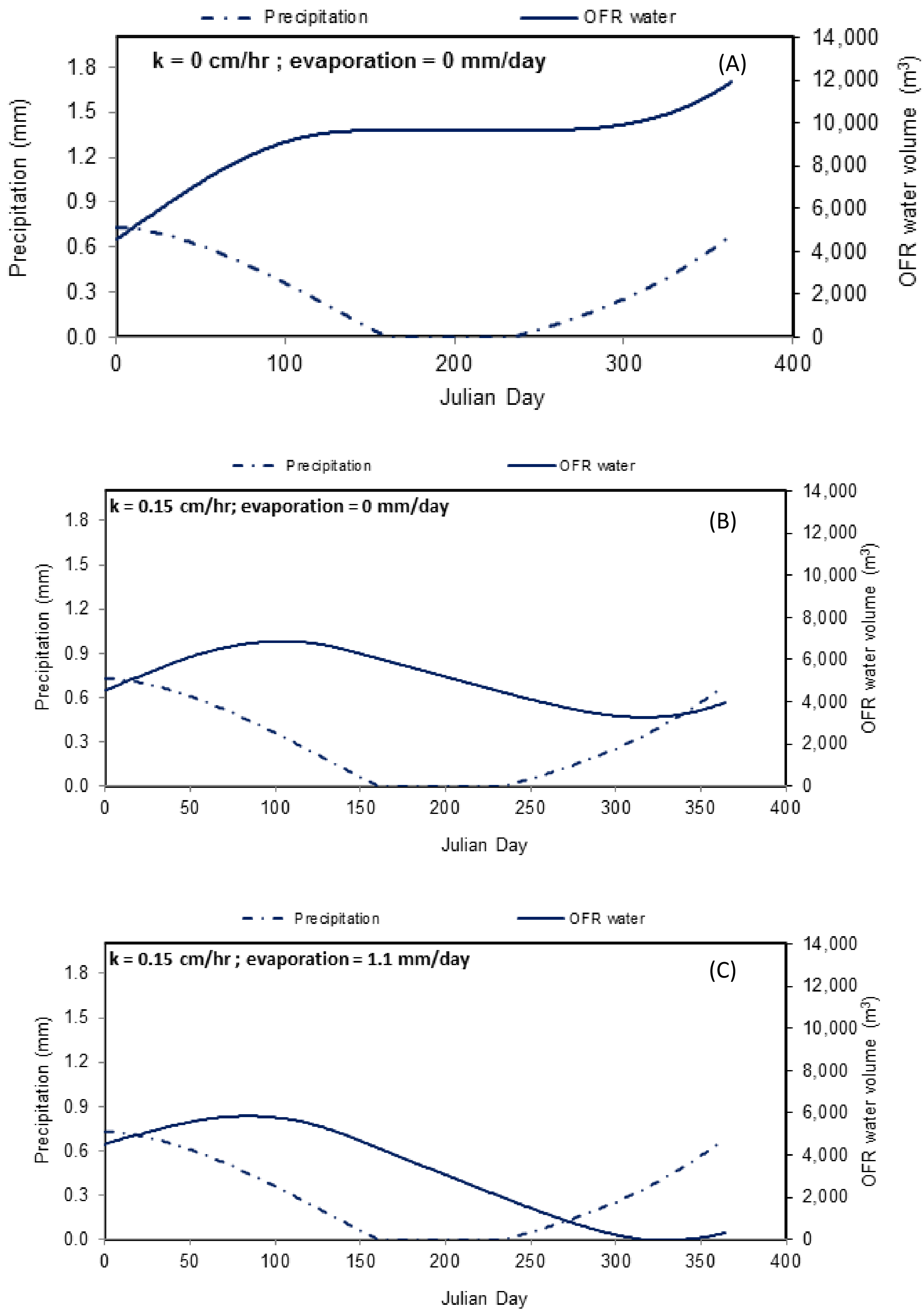

Fig. 4. Water storages in reservoir: A) no seepage and evaporation; B) with seepage and no evaporation; C) with seepage and evaporation.

Conclusions

Rainwater harvesting from impervious surface can be an option for enhancing the water resources in Jordan. Here we used a model to understand the rainwater storages in the rainwater harvesting tank. Results showed that rainwater storages in the reservoir will critically depends on the seepage and evaporation. Controlling evaporation will enhance the water availability in reservoirs considerably. Further studies based on field experiment will certainly enhance the results presented here, and can help improving the existing rainwater harvesting structures in Jordan. We anticipate that the analysis and modelling tool suggested here will help improving the understanding of rainwater harvesting potential in Jordan, and deriving the improved rainwater harvesting facilities.

Acknowledgment

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