Solar Pond

Iraq as a Case Study

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Water is important to life. Man has been dependent on rivers, lakes, and underground water for his requirements. About 97% of the earth water is salty and only 3% of earth water is potable. Due to increase in population and rapid industrial growth, the consumption of fresh water is increasing day by day.

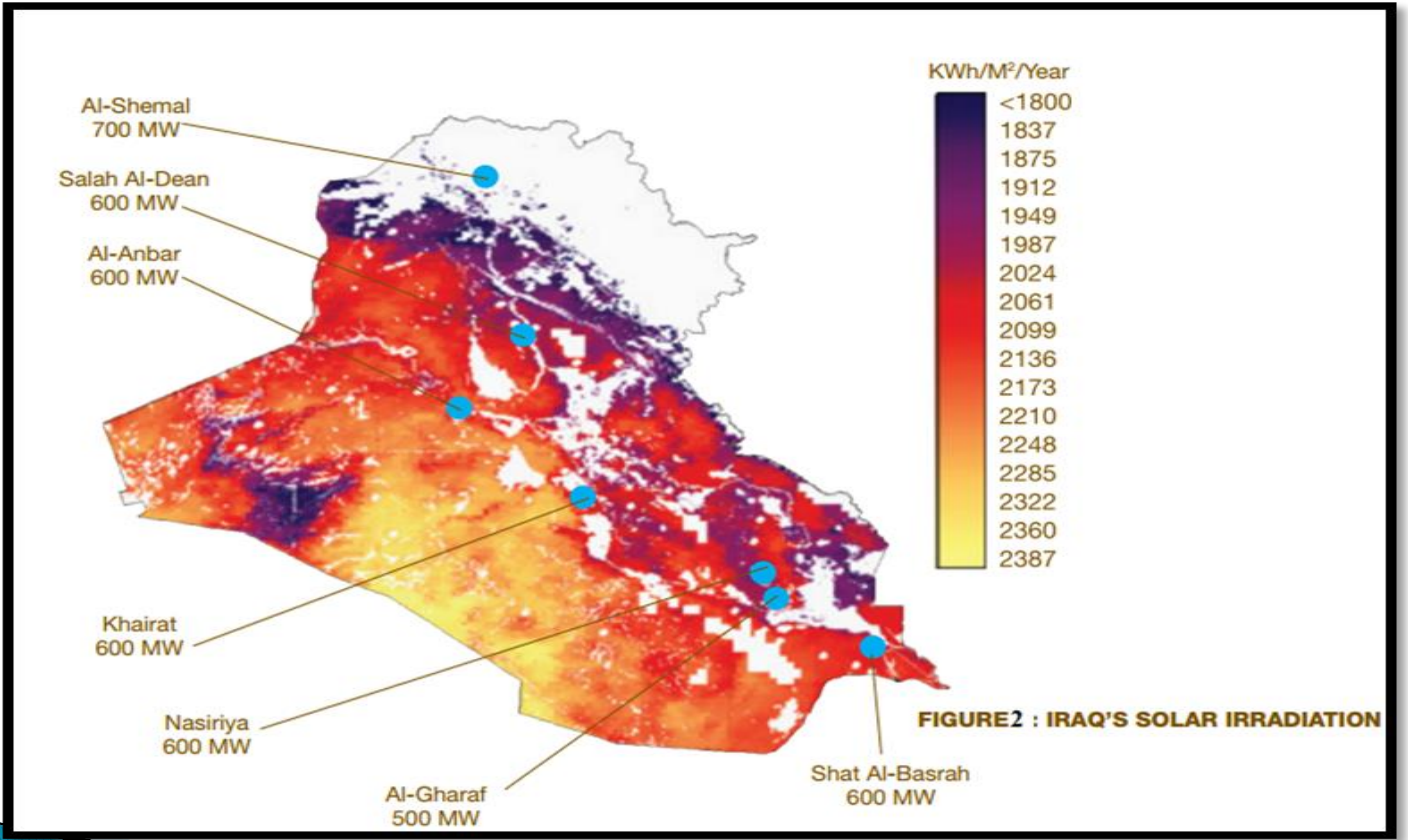
Desalination is the best solution for the above said problem. In existing desalination method, for mass production, fossil fuels are used. But availability of fossil fuels in the world is very limited.

Introduction

- A solar pond is simply a pool of saltwater which collects and stores solar thermal energy.
- One of the most interesting ways to generate solar thermal energy is through the use of a solar pond. A solar pond is a pond full of saltwater that is used for capturing and storing solar heat.
- Solar energy is an abundant and renewable energy source.
- A solar pond can be used for various applications, such as process heating, desalination, refrigeration, drying and solar power generation.

… Introduction

- Iraq has excellent solarity, ranging from 1800 to 2390 $kw/m^2/yr$.
- This solar energy can be used as a new technology of solar pond and its application to desalination of reverse osmosis rejects in south of Iraq.


Al-Shemal
700 MW
Salah Al-Dean
600 MW
Al-Anbar
600 MW
Khairat
600 MW
Nasiriya
600 MW
Al-Gharaf
500 MW
Shat Al-Basrah
600 MW
KWh/M²/Year
<1800
1837
1875
1912
1949
1987
2024
2061
2099
2136
2173
2210
2248
2285
2322
2360
2387
FIGURE2 : IRAQ'S SOLAR IRRADIATION

… Introduction

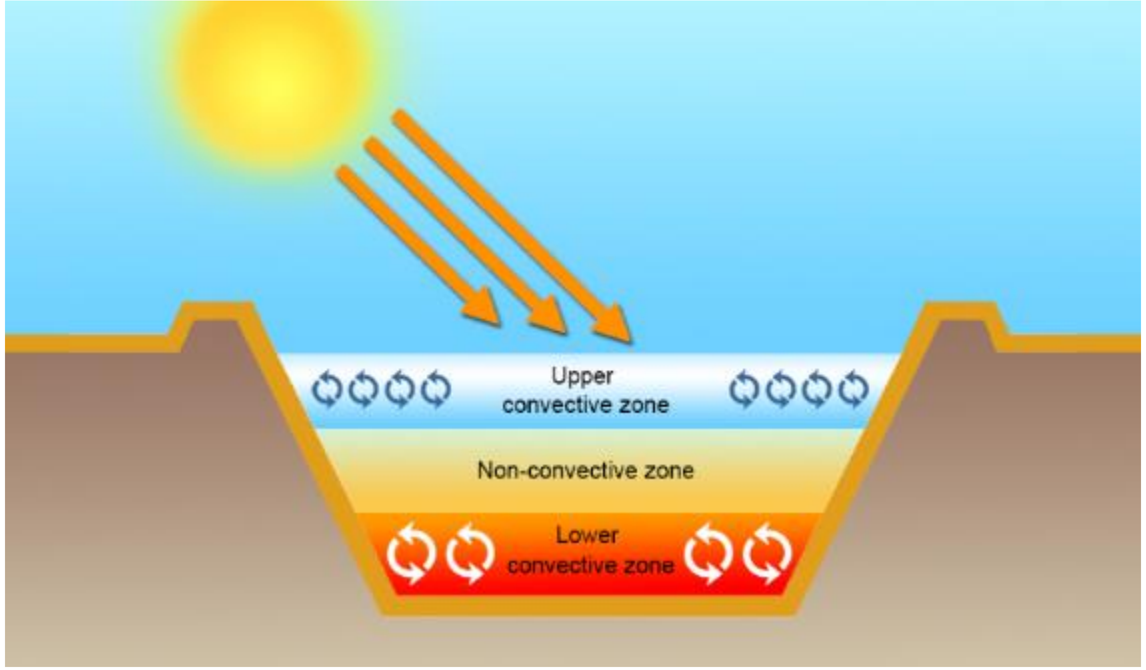
- **In a clear natural pond about 30% solar radiations reaches a depth of 2 meters.**
- **This solar radiation is absorbed at the bottom of the pond.**
- **The hotter water at the bottom becomes lighter and hence rises to the surface. Here it loses heat to the ambient air and, hence, a natural pond does not attain temperatures much above the ambient.**
- **If some mechanism can be devised to prevent the mixing between the upper and lower layers of a pond, then the temperatures of the lower layers will be higher than of the upper layers.**

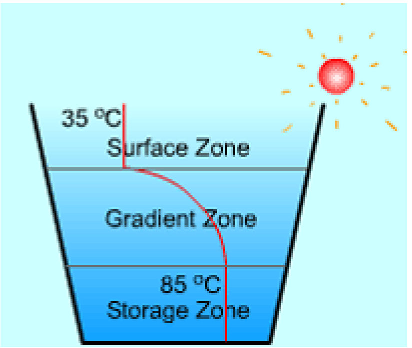
General Energy Balance for Solar Pond

$$Q_{net} = Q_{accumulation} = Q_{in} - Q_{out}$$

$$Q_{in} = Q_{solar} + Q_{bottom}$$

$$Q_{out}\ \text{(heat loss)} = Q_{wall} + Q_{to\ surrounding}$$

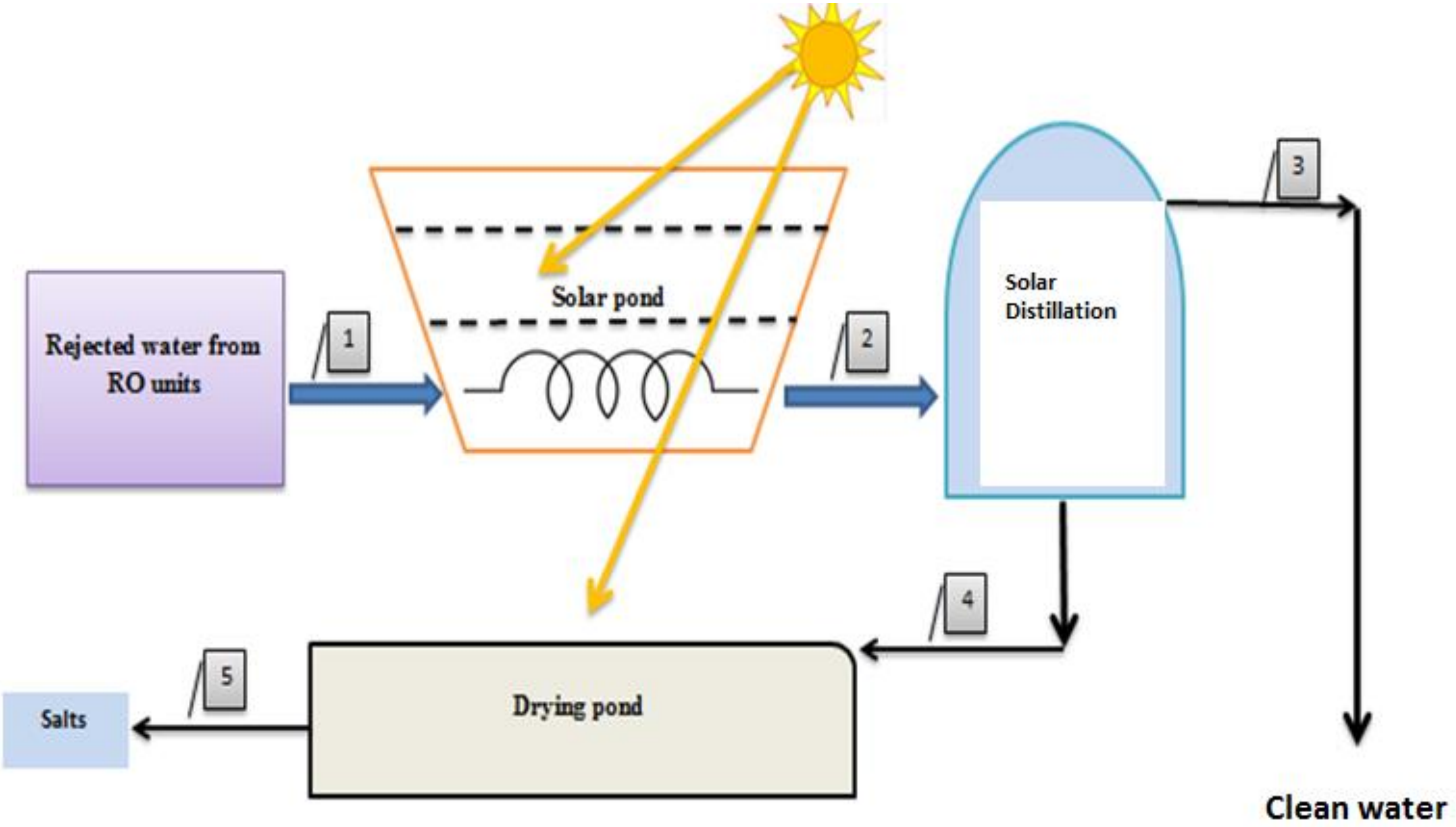


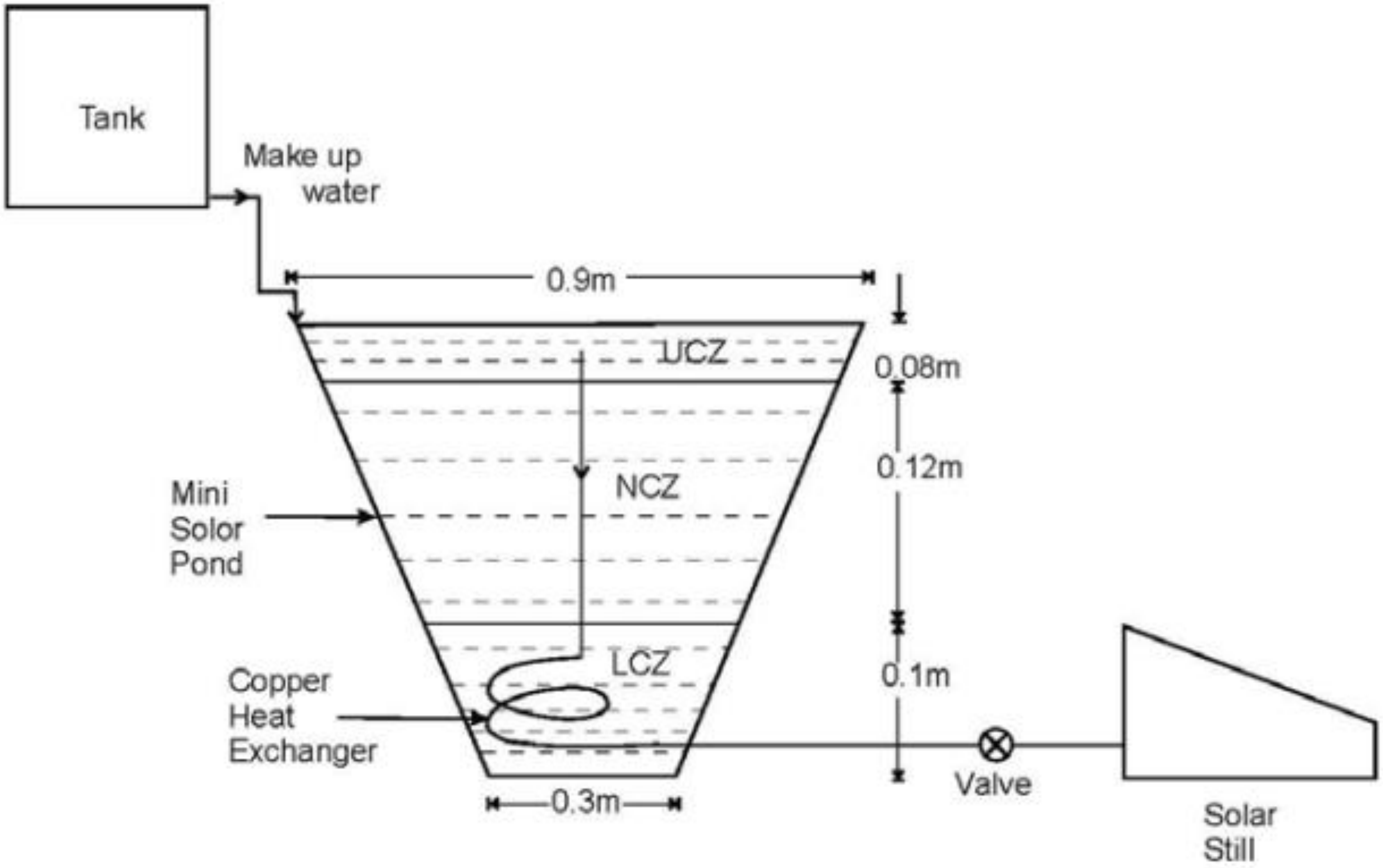


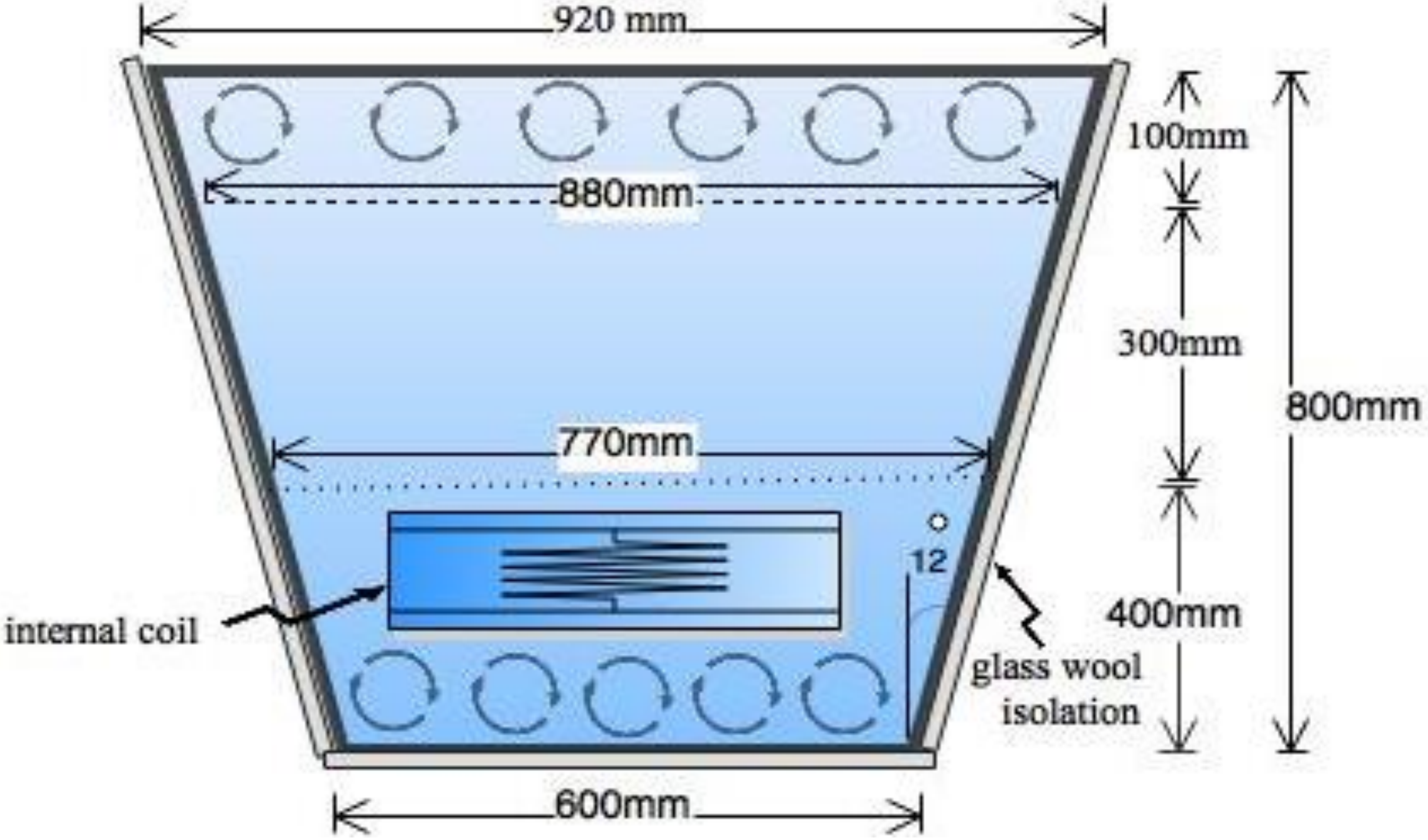
PROBLEM STATMENT

The rejection solution (reject streams) normally out from reverse osmosis (R.O) units, membrane (R.O) unite have high solute concentration than that in R.O feed water. This concentration increasing could be reached up to 50%.The rejection solution mainly in all desalination projects using reverse osmosis membranes technology are disposed to the project raw water stream which may affect the on water sources in term of increasing the salinity and influence on Marian life.

Aim of the work




Tank
Make up water
0.9m
UCZ
0.08m
NCZ
0.12m
Mini Solor Pond
LCZ
0.1m
Copper Heat Exchanger
Valve
0.3m
Solar Still


920 mm
100mm
880mm
300mm
800mm
770mm
12
internal coil
400mm
glass wool
isolation
600mm

Solar still fabrication
Dimensions :
Breadth(width) =102 cm
Length = 69 cm
Height (front) =22 cm
Height (back) = 42 cm
Angle (θ) = 31°

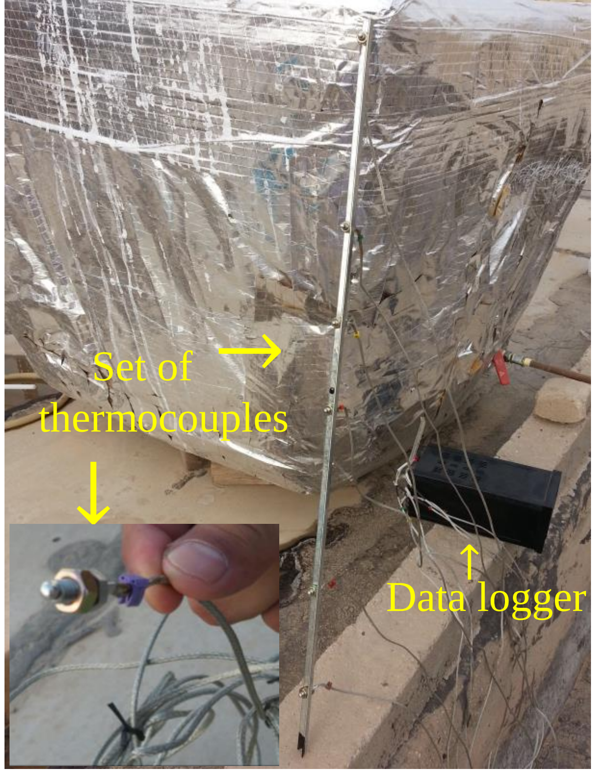
Epoxy lining for solar still
Three layers epoxy coated
Food grade type

Glass sheet fixed at solar still
With thermocouples to indicate temperatures

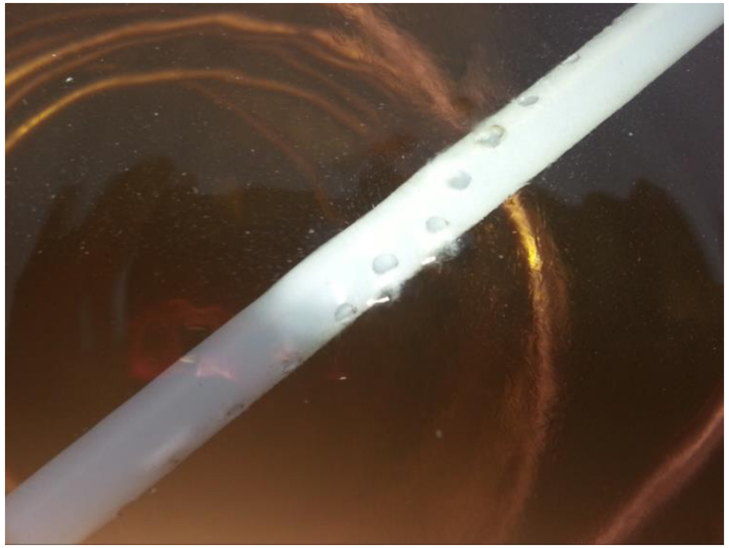
Solar pond (Trapezoidal shape) manufacturing
Base dimensions = 60×60 cm
Top surface dimensions = 92×92 cm
Height = 86 cm
obliqueness angle (θ) = 12°

Internal coil exchanger fixed inside solar pond at lower layer (heat store layer)
Diameter = 3/8 inch
Length = 10 m

Coal tar Epoxy lining and double layers of Isolation glass wool (5 cm thick)



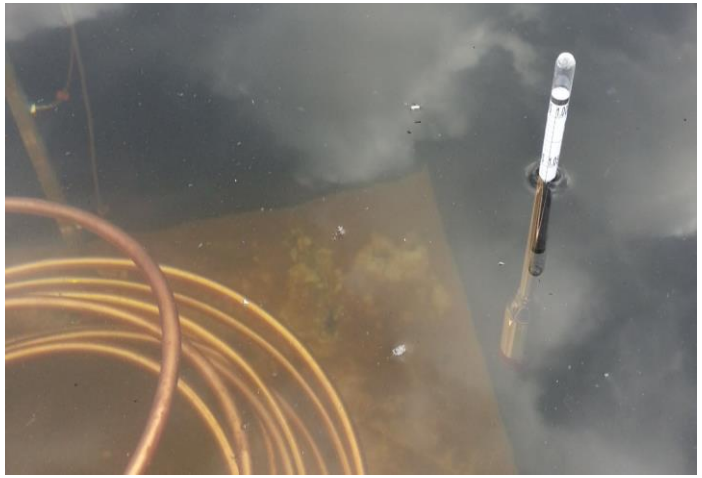
Set of thermocouples group fixed Solar pond inside and connected to Data logger



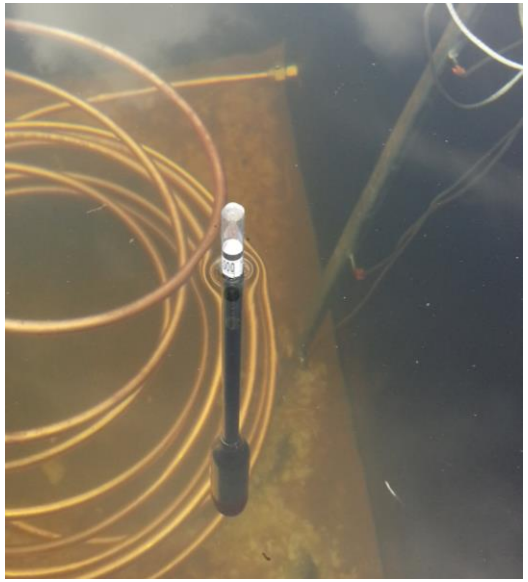
Hydrometer-Areometer

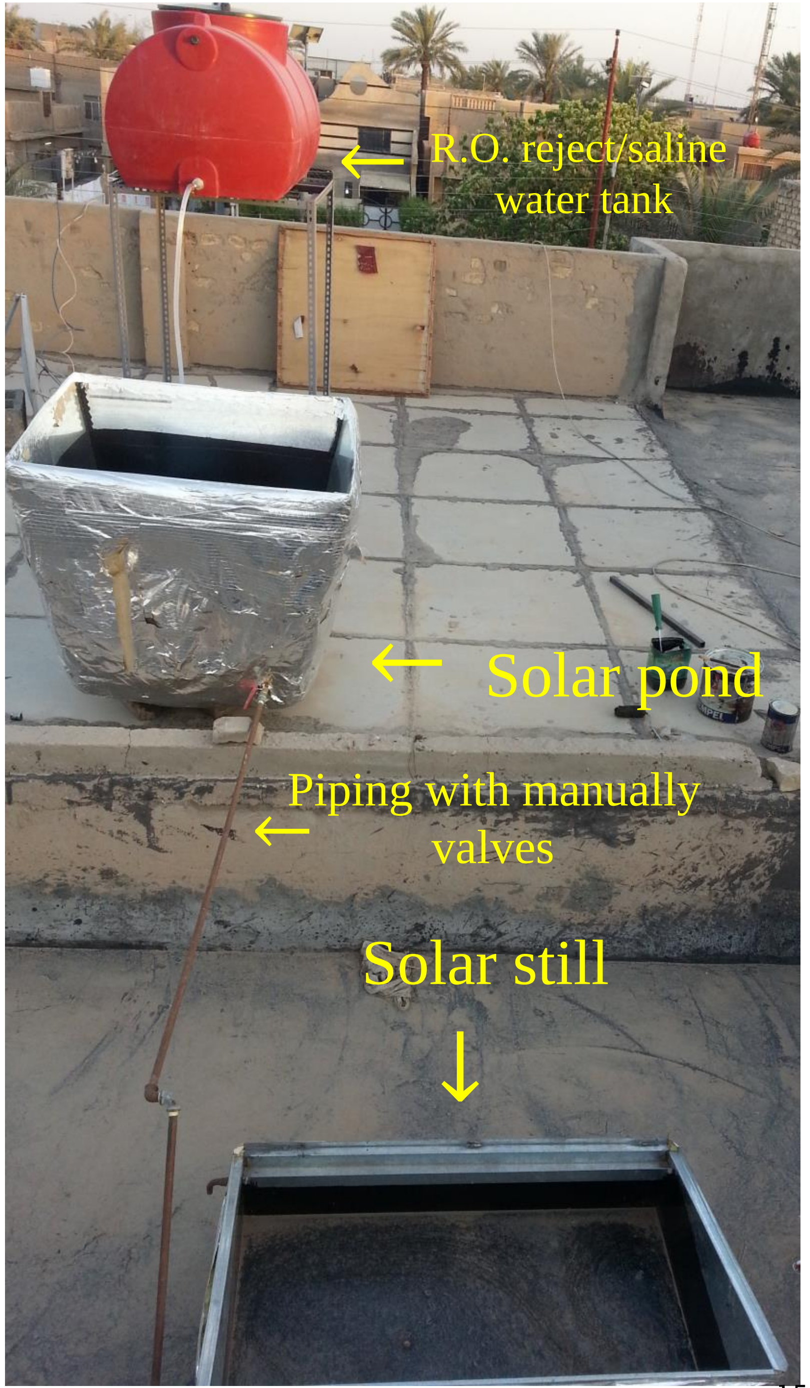
Preparing the solution
Of lower layer

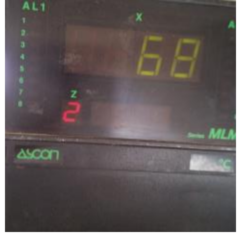
plastic perforated pipe (diameter = 20mm)
To fill solar pond



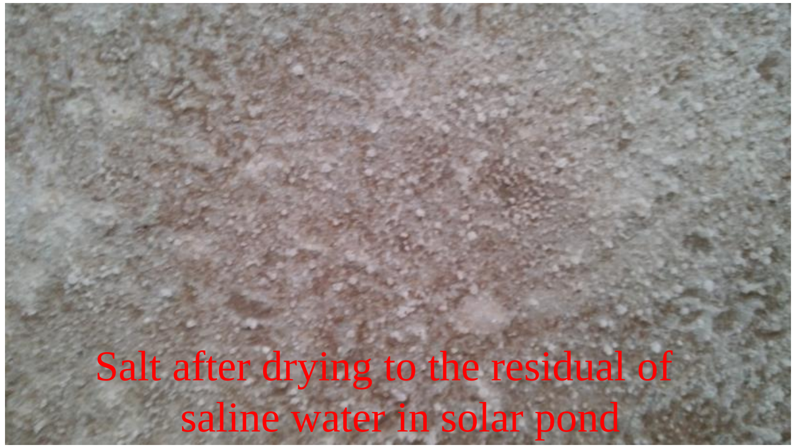
Different concentration for the intermediate (gradient) layer







Some of indications for temperatures at lower layer which stability at 63 ,64 °C

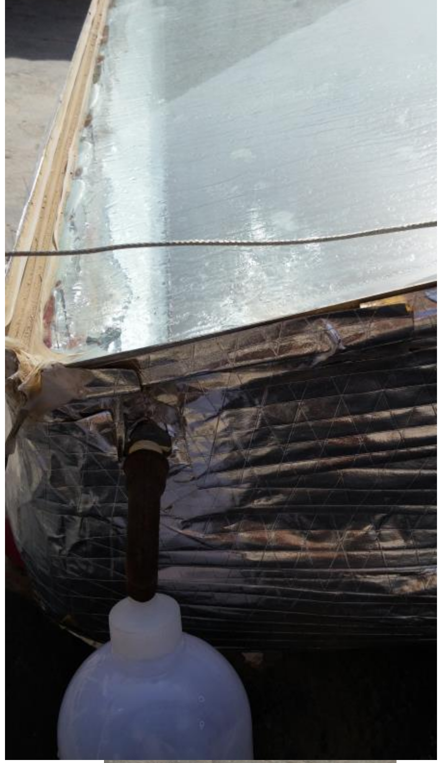


Salt after drying to the residual of saline water in solar pond

Effect of sunshade on productivity of water

Confirm of plastic cover above solar pond
To reduce make up water at upper layer
Due to evaporation

Distilled water
TDS = 110 ppm



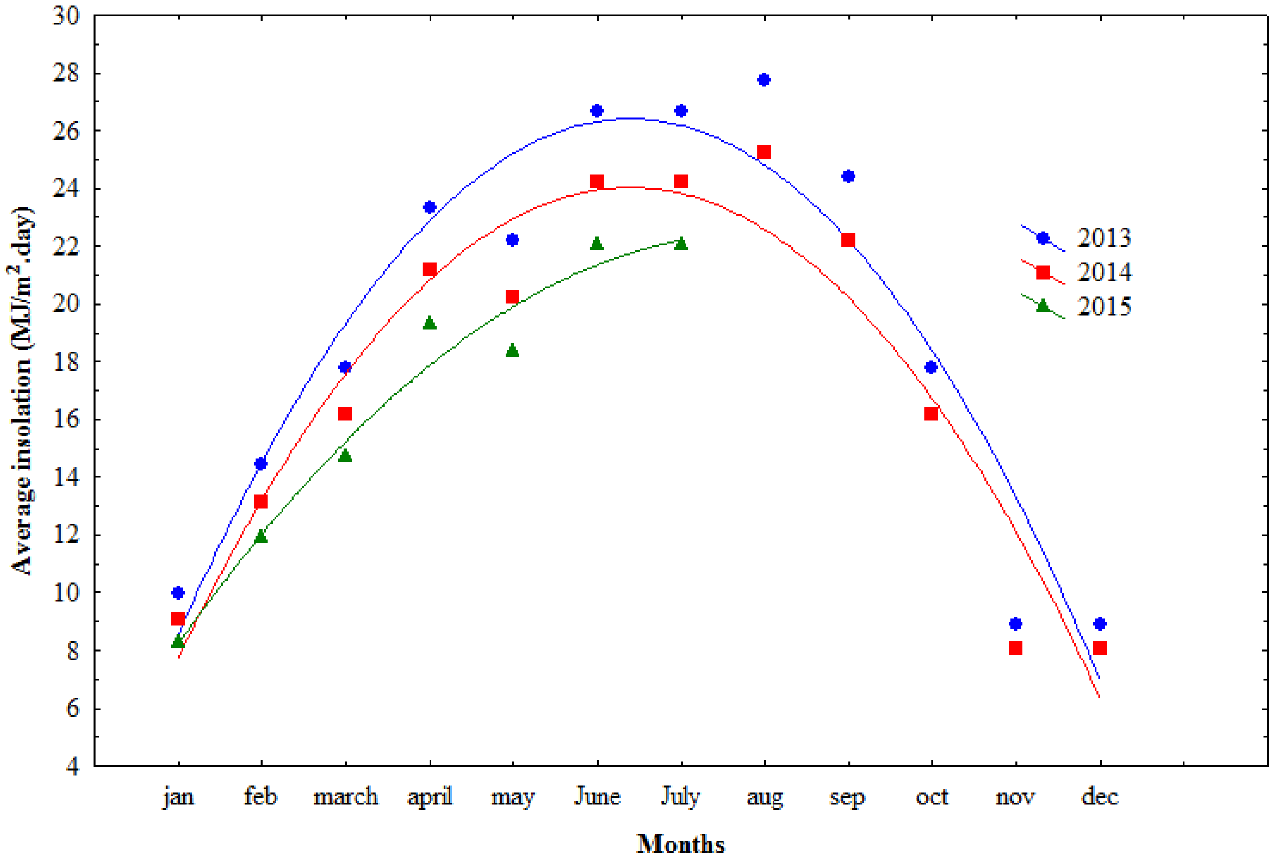
↑ ↑

Many times in different days of condensation process
at solar still glass

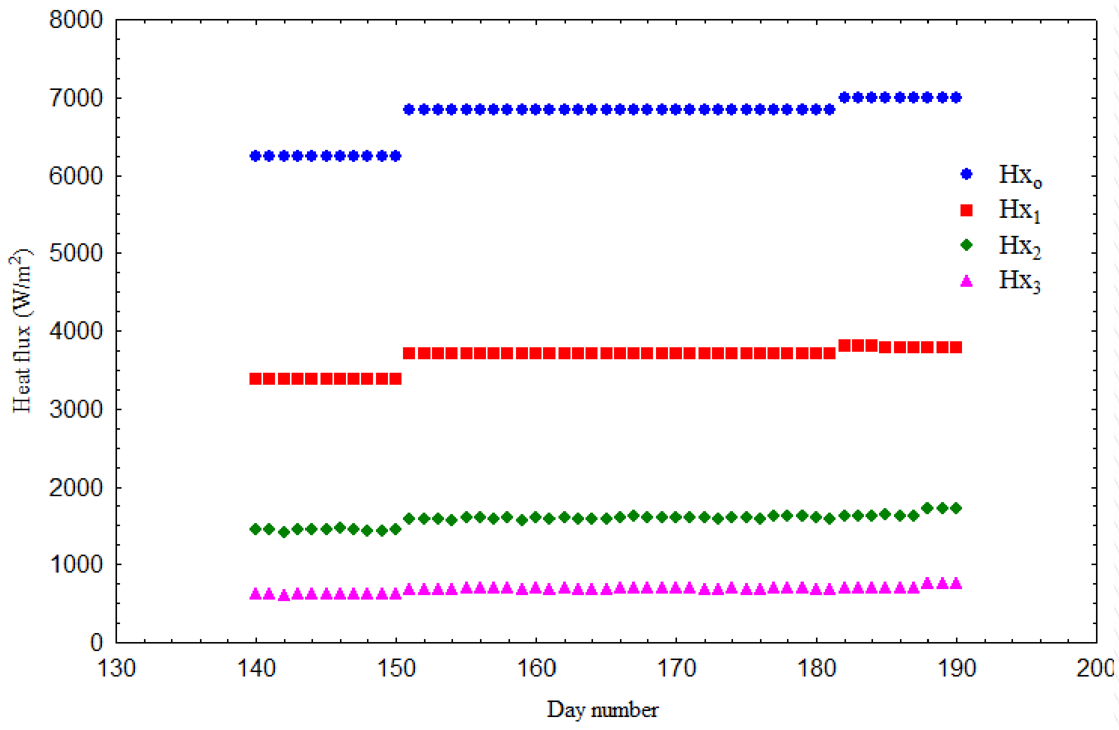
↓ ↓

Water collection jar
Measuring bottle

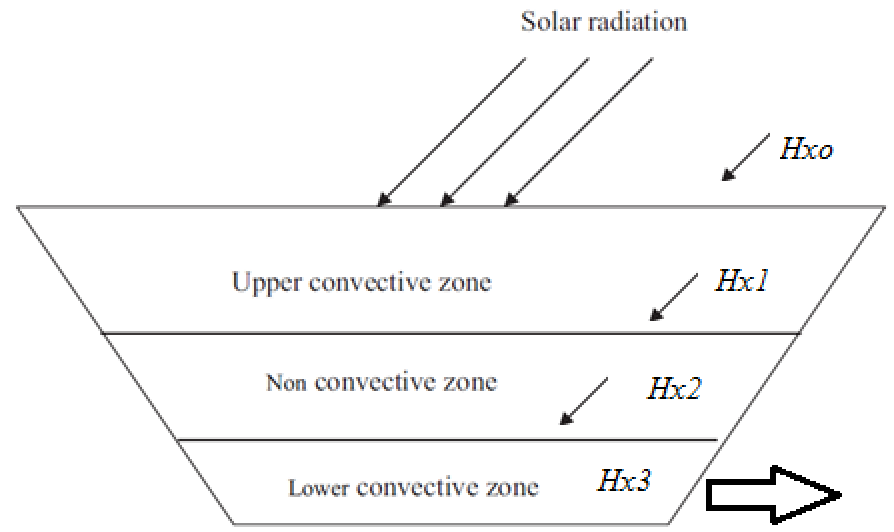
Results – Solar Pond



Average insolation in Baghdad

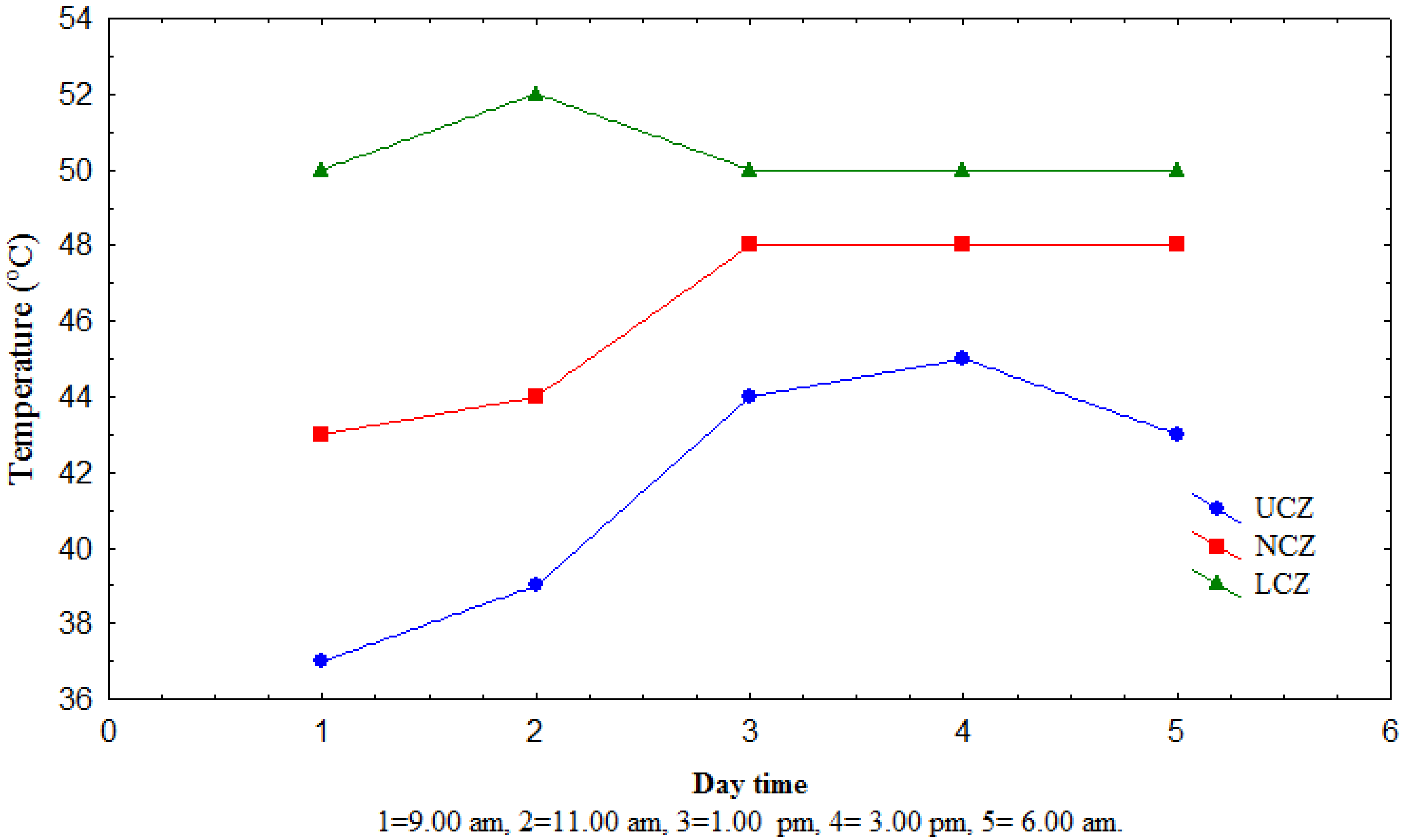


Heat flux to the solar pond as a function of depth (x) and day number in the year 2015



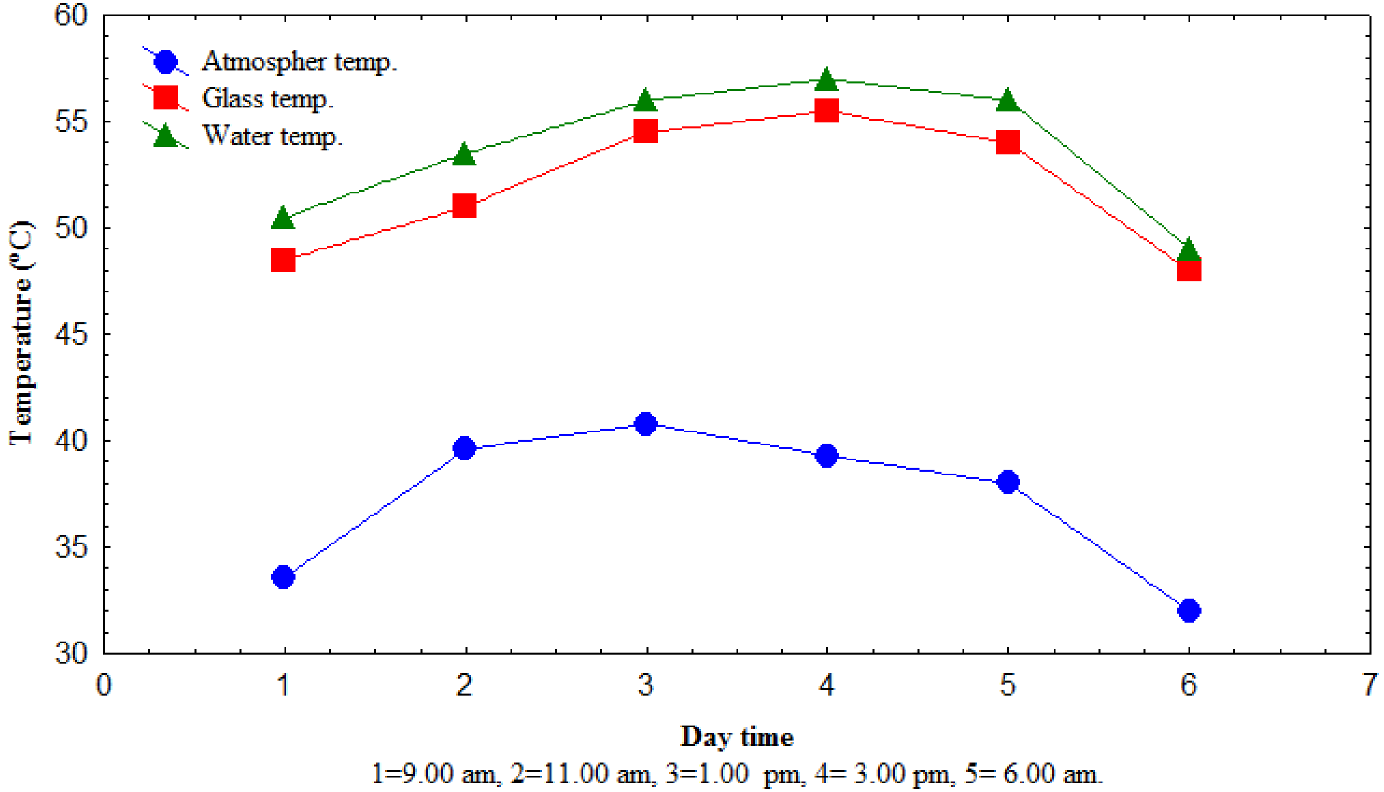
Heat flux to each zone

Solar pond diagram

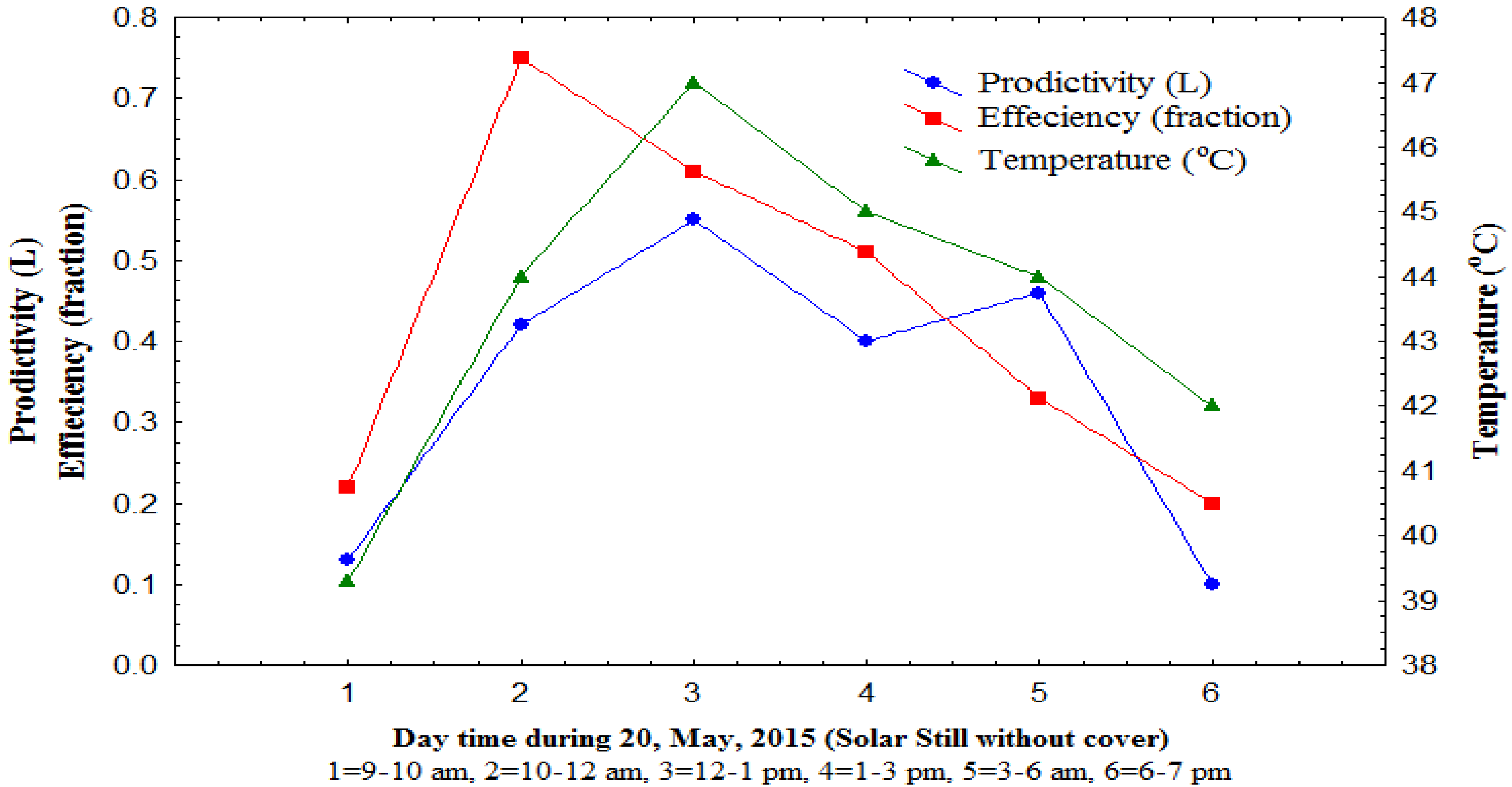


Temprature distribution in layers of solar pond during 10, June, 2015.

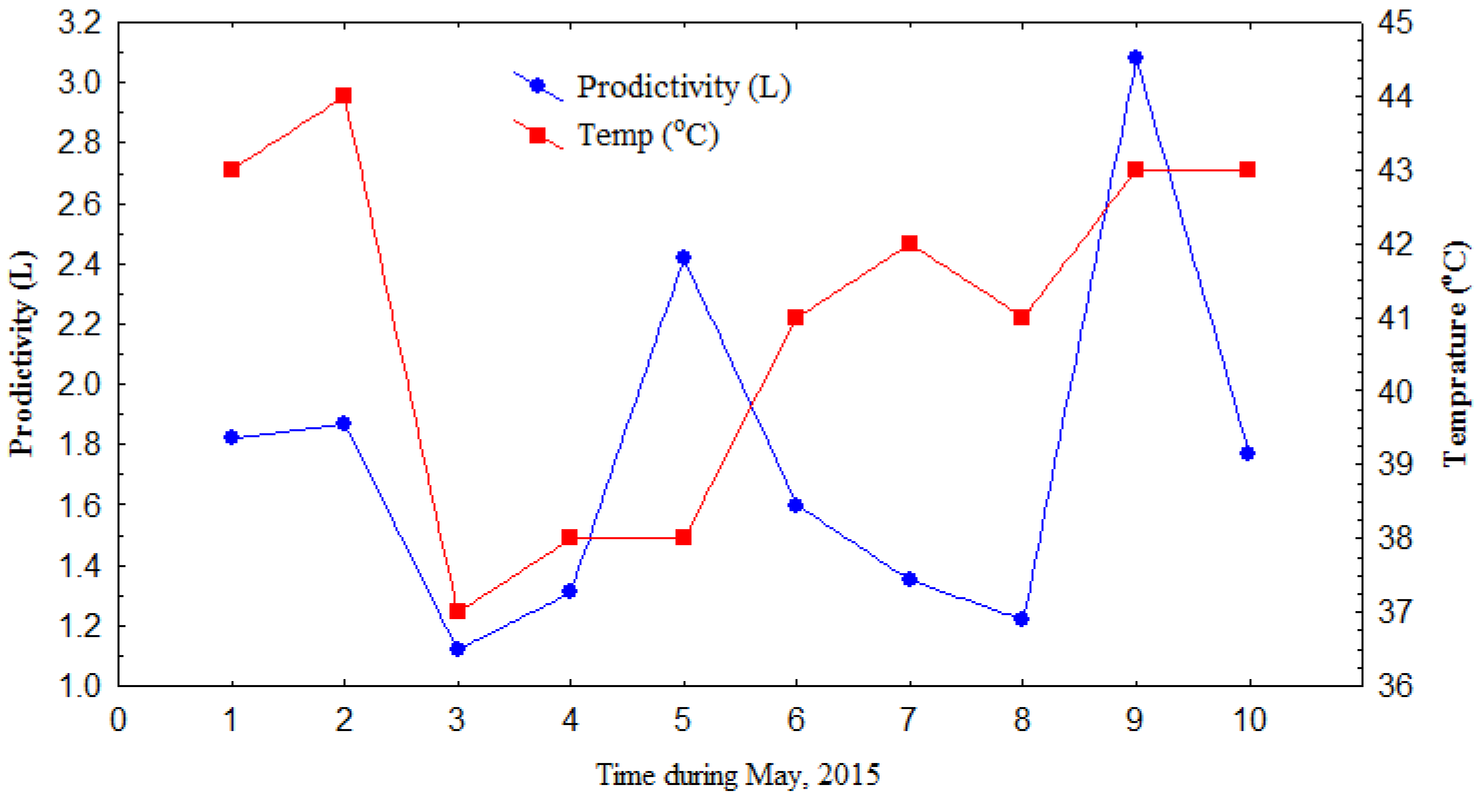
Results – Solar Still



Temprature distribution in solar still in presence of solar pond effect during 15, June, 2015.

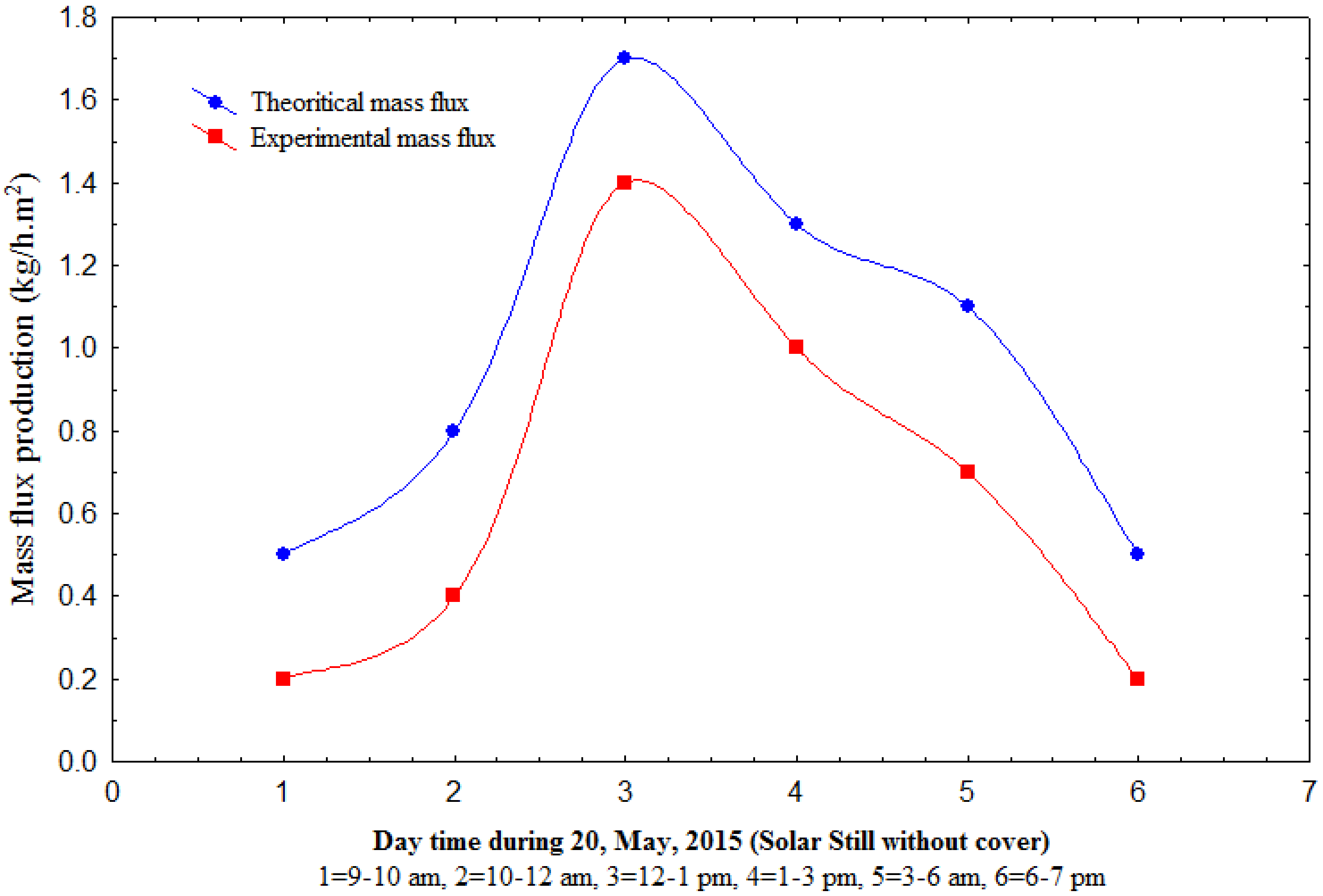


Productivity and effeciency of solar still as a function of time and temprature

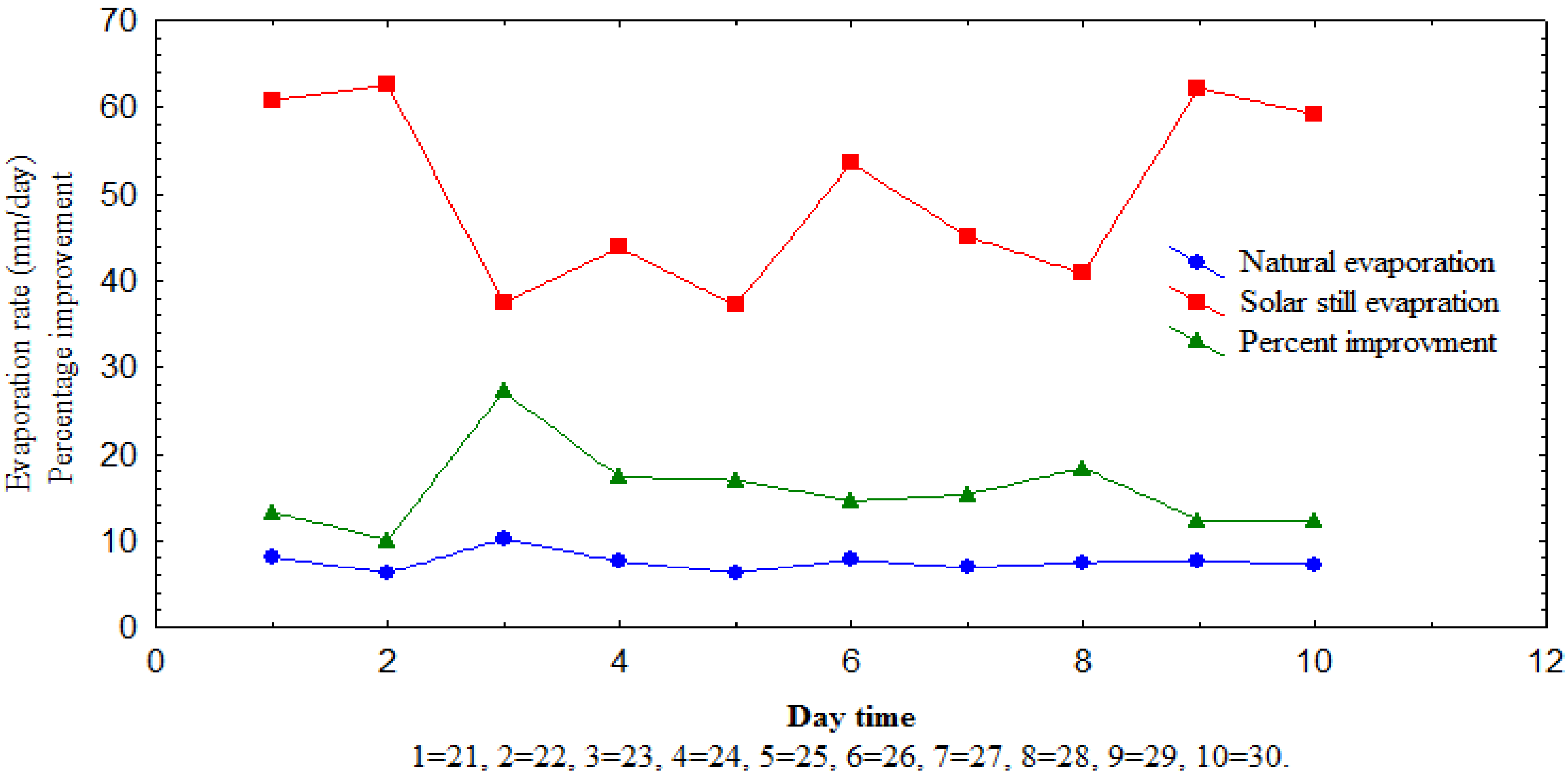


1=20 May, 2=21May, 3=22 May, 4=23May, 5=24May
6=25May, 7=26May, 8=27 May, 9=29May, 10=29May

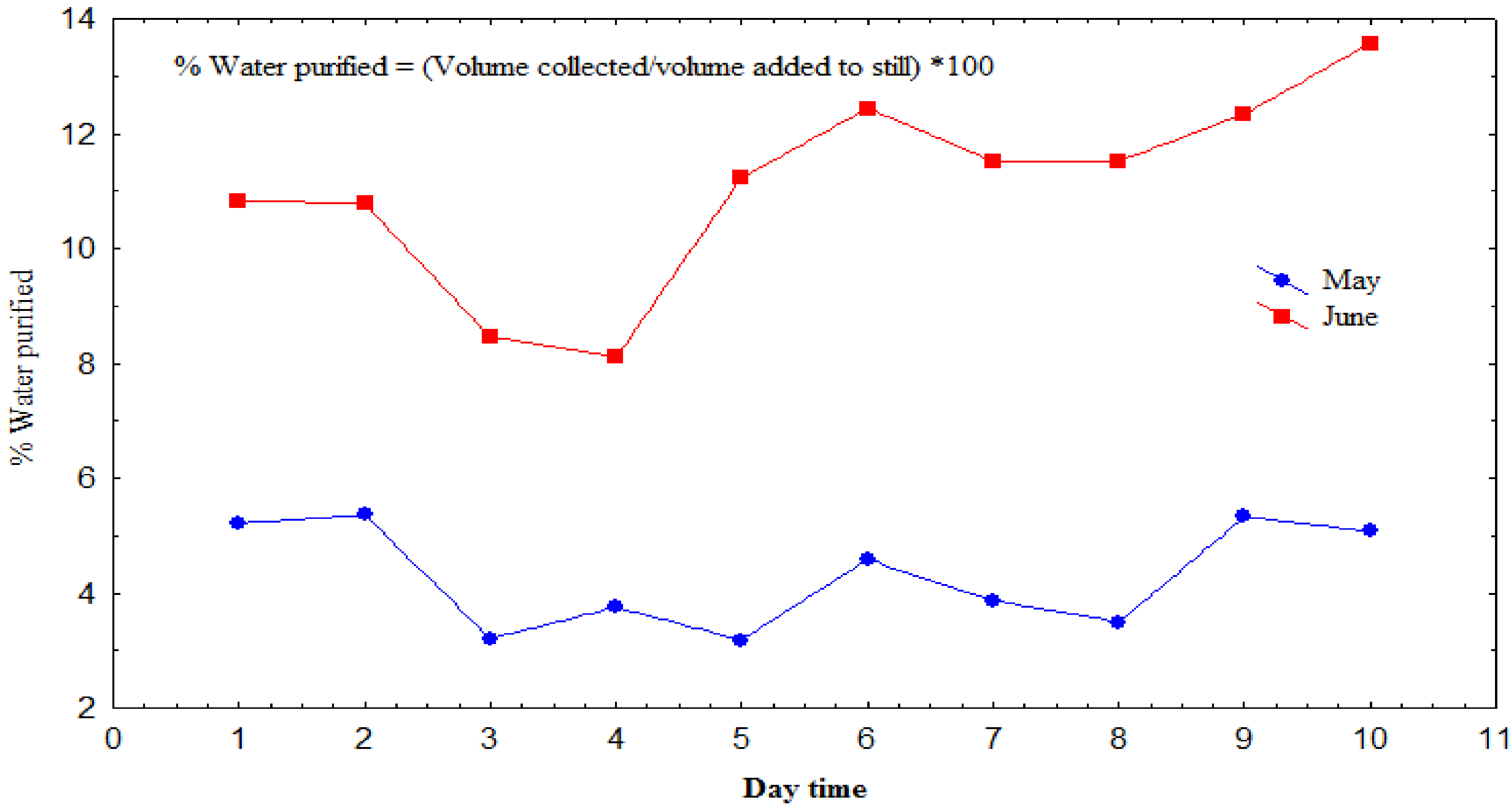
Accumilative productivity of distilled water from solar still in absence of solar pond effect during ten days of May, 2015.



Production of distilled water from solar still without solar pond connection



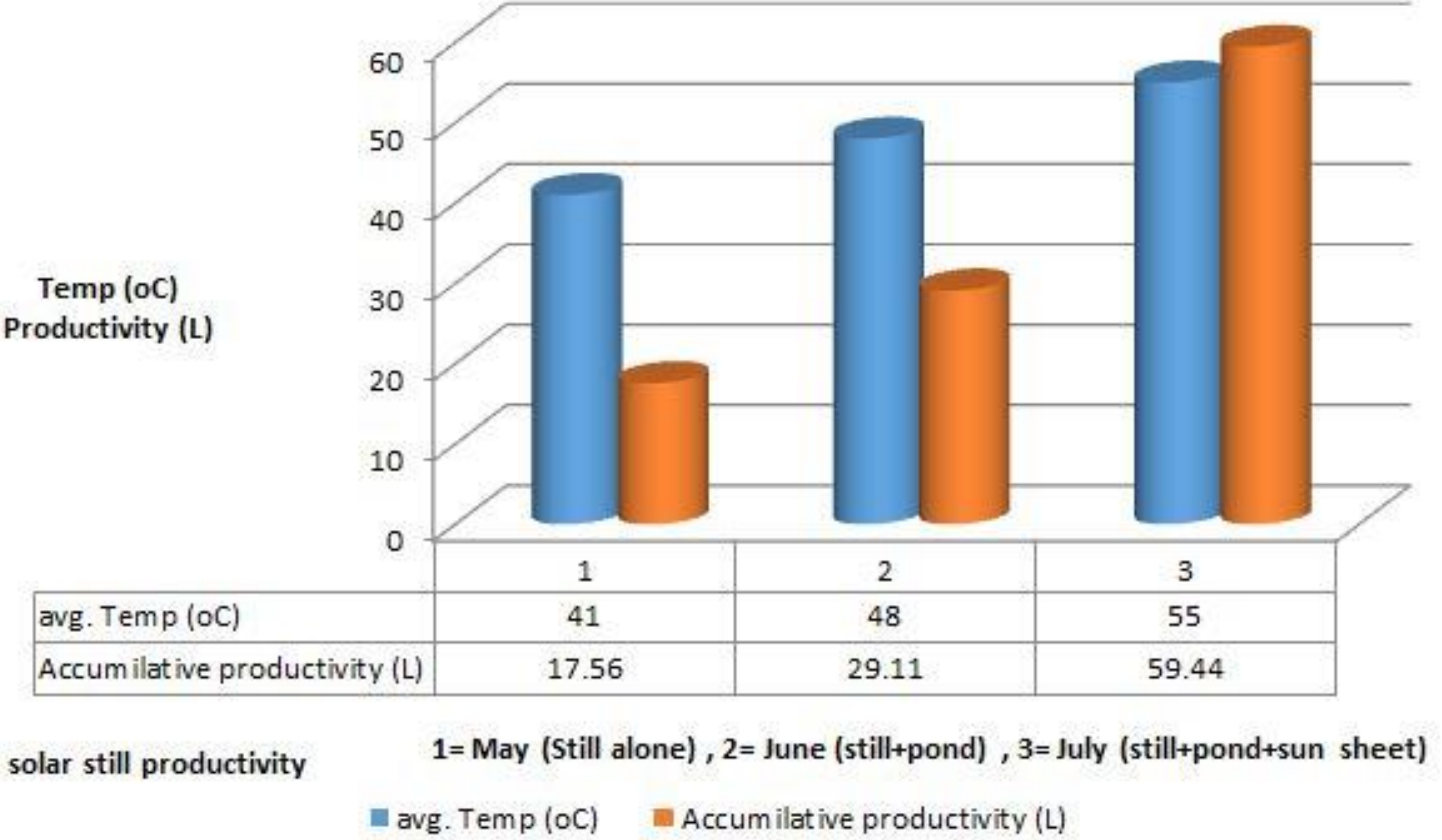
Comparsion of natural evaporation with solar still evaporation and percent improvment in solar still in absence of solar pond and sun sheet effect during May, 2015.



1=21, 2=22, 3=23, 4=24, 5=25, 6=26, 7=27, 8=28, 9=29, 10=30.

Percent water purification via solar still in absence of solar pond and sun sheet effect during May and June, 2015.

$$\% \text{ water purified} = \frac{\text{volume collected}}{\text{volume added to still}} \times 100$$



	1	2	3
avg. Temp (oC)	41	48	55
Accumilative productivity (L)	17.56	29.11	59.44

Some recent examples …

This photo displays a large scale salt gradient solar pond at the University of Texas at El Paso developed by John Walton and Andrew Swift.

MAJOR SALT – GRADIENT SOLAR PONDS (in India)

Location	Area (m^2)	Depth (m)	Main Objectives	Achievements
Bhavnagar (India)	1210	1.2	Operating experience and behaviour of materials	Max. Temp. 80°C in 1972. Worked for two years.
Bhavnagar (India)	1600	2.3	Operating experience and applications for power production.	Getting heated, designed to supply 20 KW. Rankine cycle turbines.
Pondicherry (India)	100	2.0	Experience, material behaviour, monitoring & modeling.	Built in 1980.
Bhuj (India)	6000	3.0	Operating experience, material behaviour and possible applications	Supplying process heat to a dairy

THANK YOU

FOR

ATTENDING AND LISTENING