A
PRESENTATION
on
Low Cost Multi Stage Water Purification System For Large Communities Powered By Dye Sensitized Solar Cells

SARVAJANIK COLLEGE OF ENGINEERING & TECHNOLOGY
CHEMICAL ENGINEERING
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Presented by:
Mrs. Vaishali Umrigar
Assistant Professor,SCET,SURAT

Prepared By: Mrs.Vaishali Umrigar
Abhimanyu Rathi
Vikas Mishra
Parwathi Pillai

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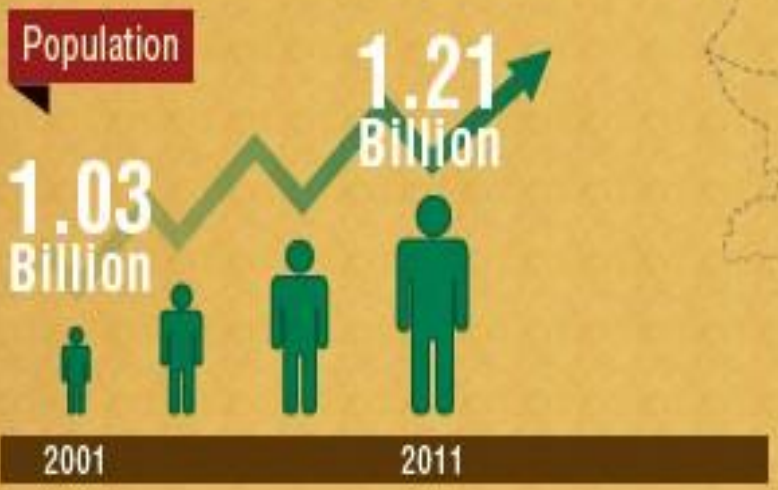
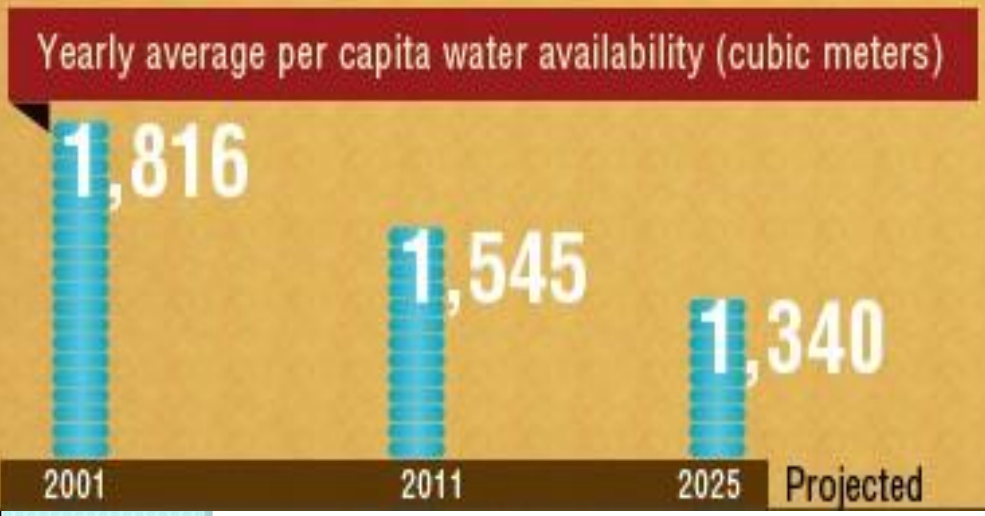
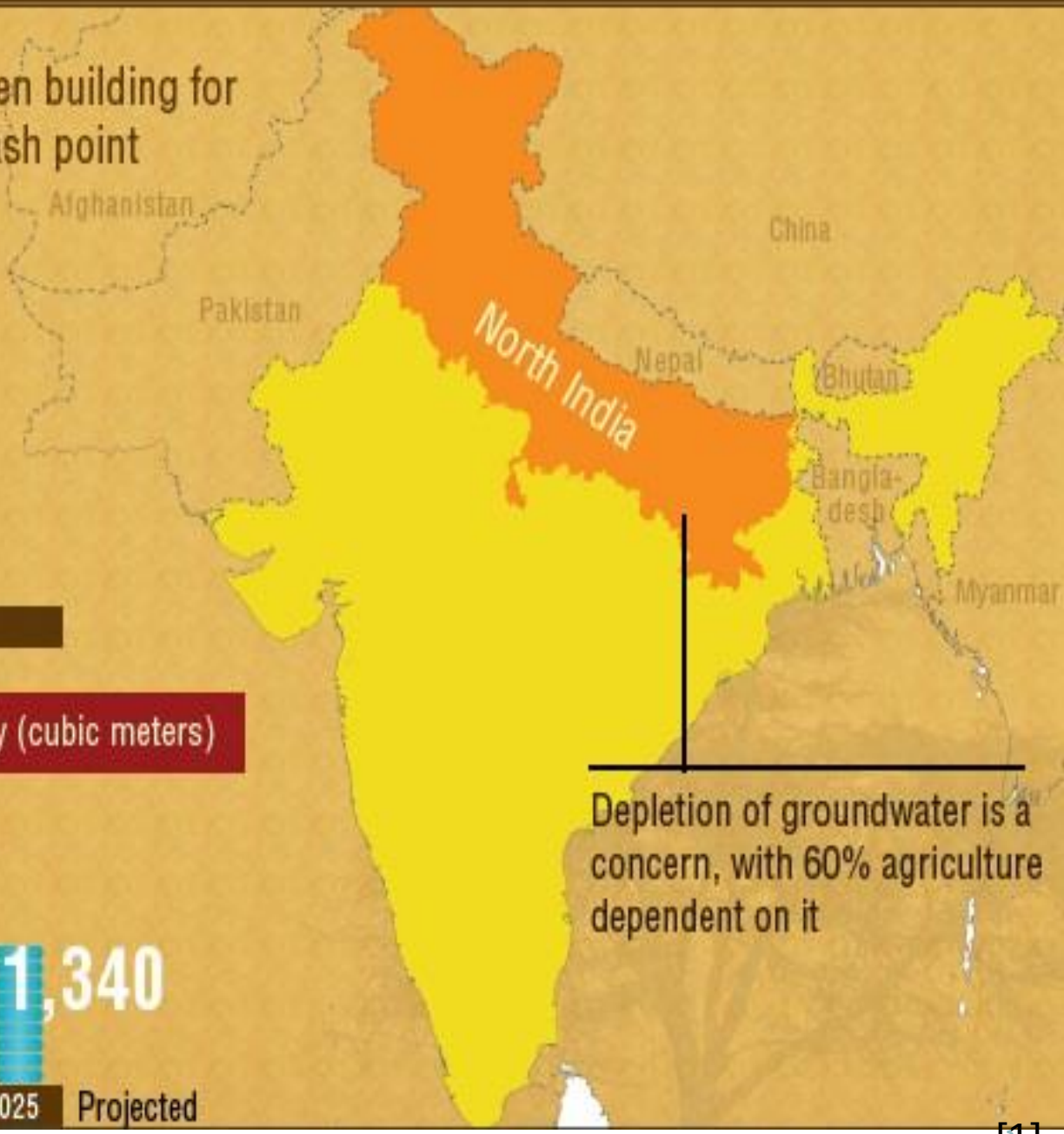
- Problems with Drinking Water in Large Communities and Rural Segments
- Our Proposed Solution for Potable Water
- Different Designs and the Final System
- Solar based Power System
- Overall Results – Parameters, Designs and Costs
- Scope for Further Development
- Review

INDIA

India faces a water crisis that's been building for decades, and may soon reach a flash point







[1]

The Problem

- Every year, nearly 6,00,000 children in India die of illnesses associated with unclean drinking water. In spite of this, 2 out of every 3 households still do not treat their drinking water and half of the rural water supply, where 70 percent of India's population lives, is routinely contaminated with toxic bacteria. [2]

- People are aware of the dangers of contaminated water, but usually do not have the means or convenience to obtain potable water. The fuel needed to boil water may not be affordable, a safe water source may not be an option at all and running a RO (reverse osmosis) system at home, may be both impractical in terms of wastage as well as economics. And then there is the increasing evidence on its effect on health. So most families continue to collect their water from contaminated sources or unreliable tap water, concerned about the safety but unable to do much about it.

The Big Question

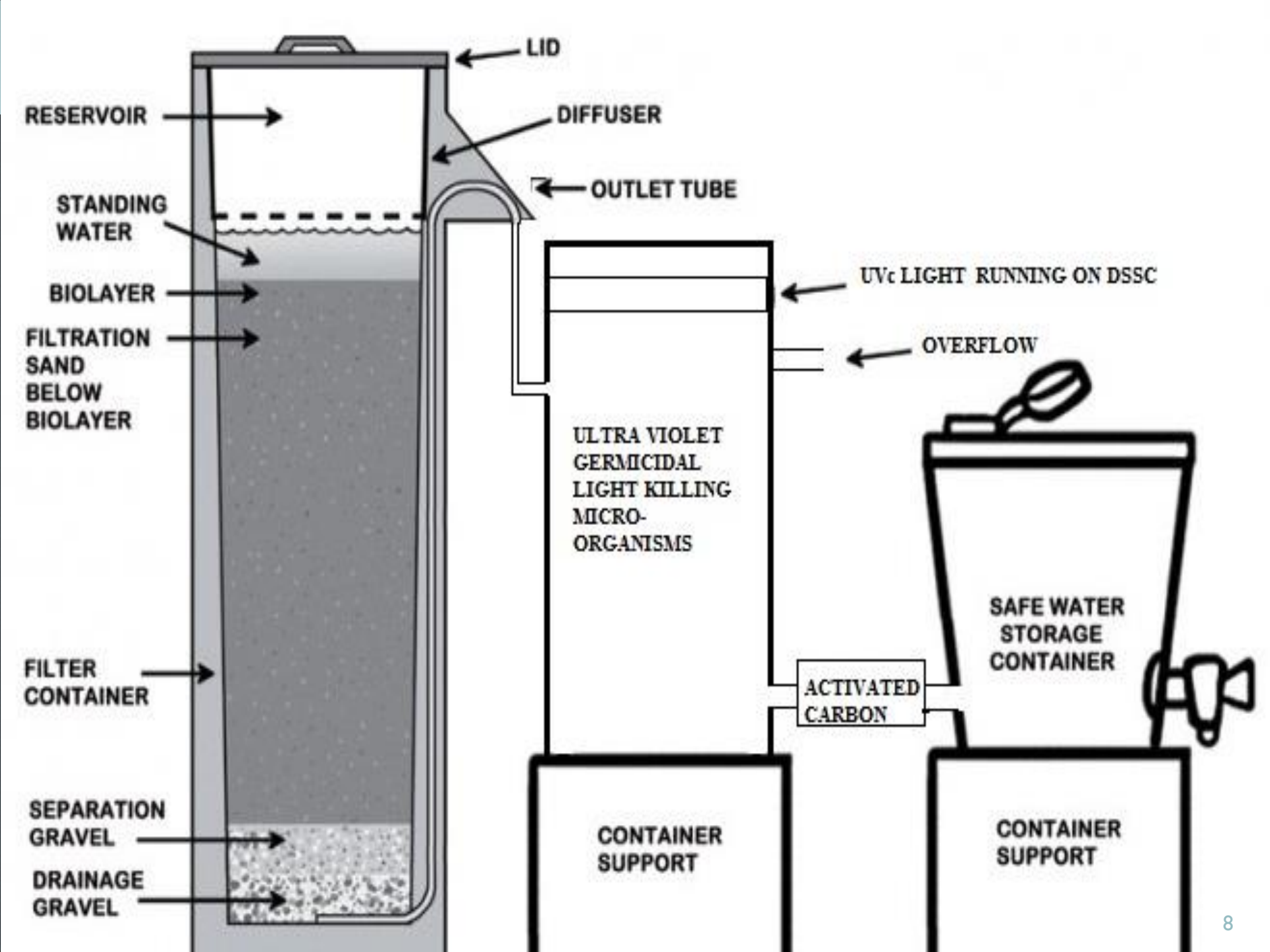
- How can we create a *Water Purification* System that *cheaply* and *portably* purifies water for rural and underprivileged large communities?

Criteria

- The apparatus must be portable.
- It must be made of cheap materials hence costing very low.
- It must be self sufficient.
- It must be durable.
- The materials must be locally available.
- It must be easy to fix if problems arise.
- It must be able to resist different climates.
- Local villagers must be able to maintain and operate it.
- It must be easy to deploy, and accessible for everyone.
- In contrast to the use of membranes, it must have a high shelf life

Our Design - A Medley of Indigenous and Advanced Technologies

- Physical Filtration: Graphite Coated (Super Sand) Sand Bed working on the principle of Bio-Sand Filtration
- Arsenic Removal: Use of Rusted Iron Nails
- Killing of the Micro-organisms: Ultra Violet Germicidal Light (UVc)
- Filtering the Dead Micro-organisms: Naturally Prepared Activated Carbon
- Bacterial Recovery: Bio-Ceramics
- Power System: Dye Sensitized Solar Cells


LID
RESERVOIR
DIFFUSER
OUTLET TUBE
STANDING WATER
BIOLAYER
FILTRATION SAND BELOW BIOLAYER
UVc LIGHT RUNNING ON DSSC
OVERFLOW
ULTRA VIOLET GERMICIDAL LIGHT KILLING MICRO-ORGANISMS
SAFE WATER STORAGE CONTAINER
ACTIVATED CARBON
FILTER CONTAINER
SEPARATION GRAVEL
DRAINAGE GRAVEL
CONTAINER SUPPORT
CONTAINER SUPPORT

The Designs We Tried

Final Design (only BSF)

Final Design (Scaled Down Model)

Some Components

Diffuser

Interior of BSF Section

Activated Carbon via Natural Ways

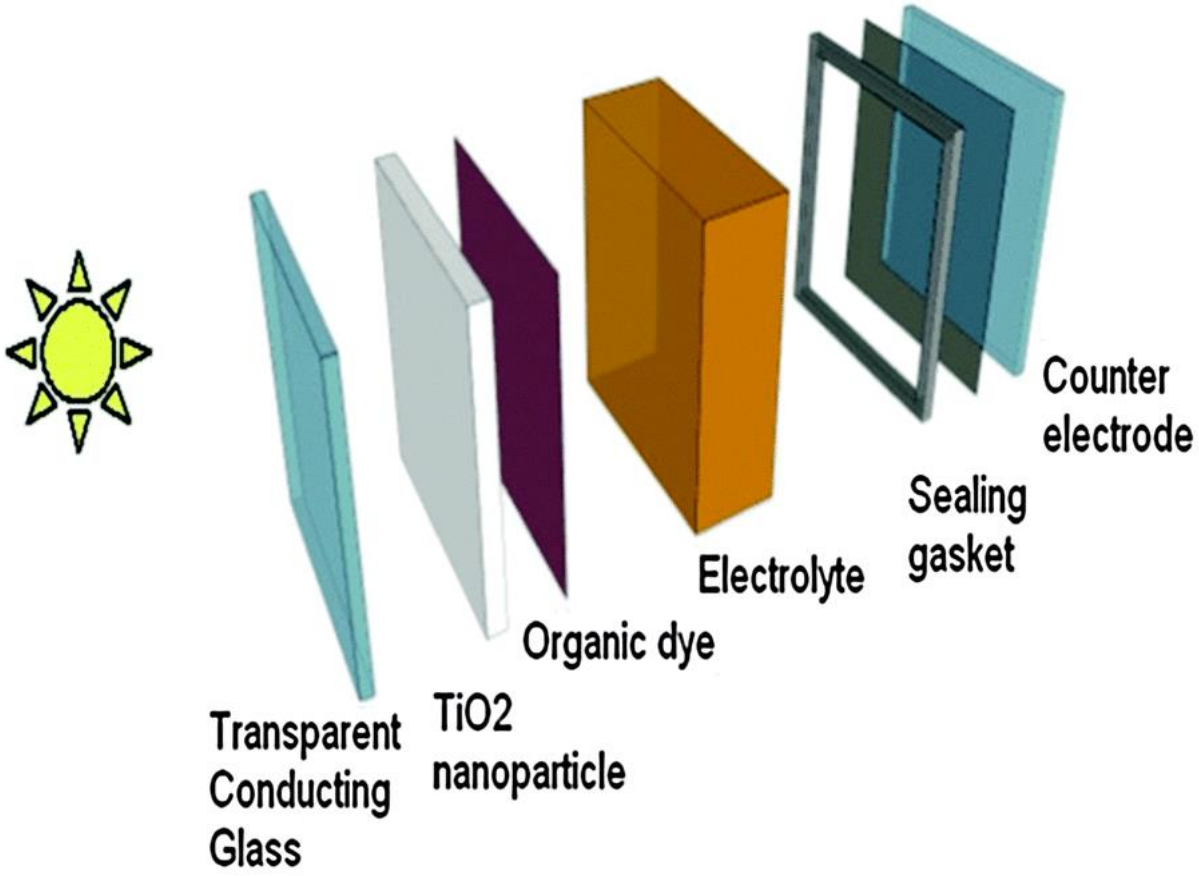
Coconut Shells

Activated Carbon

The Power System: DSSC

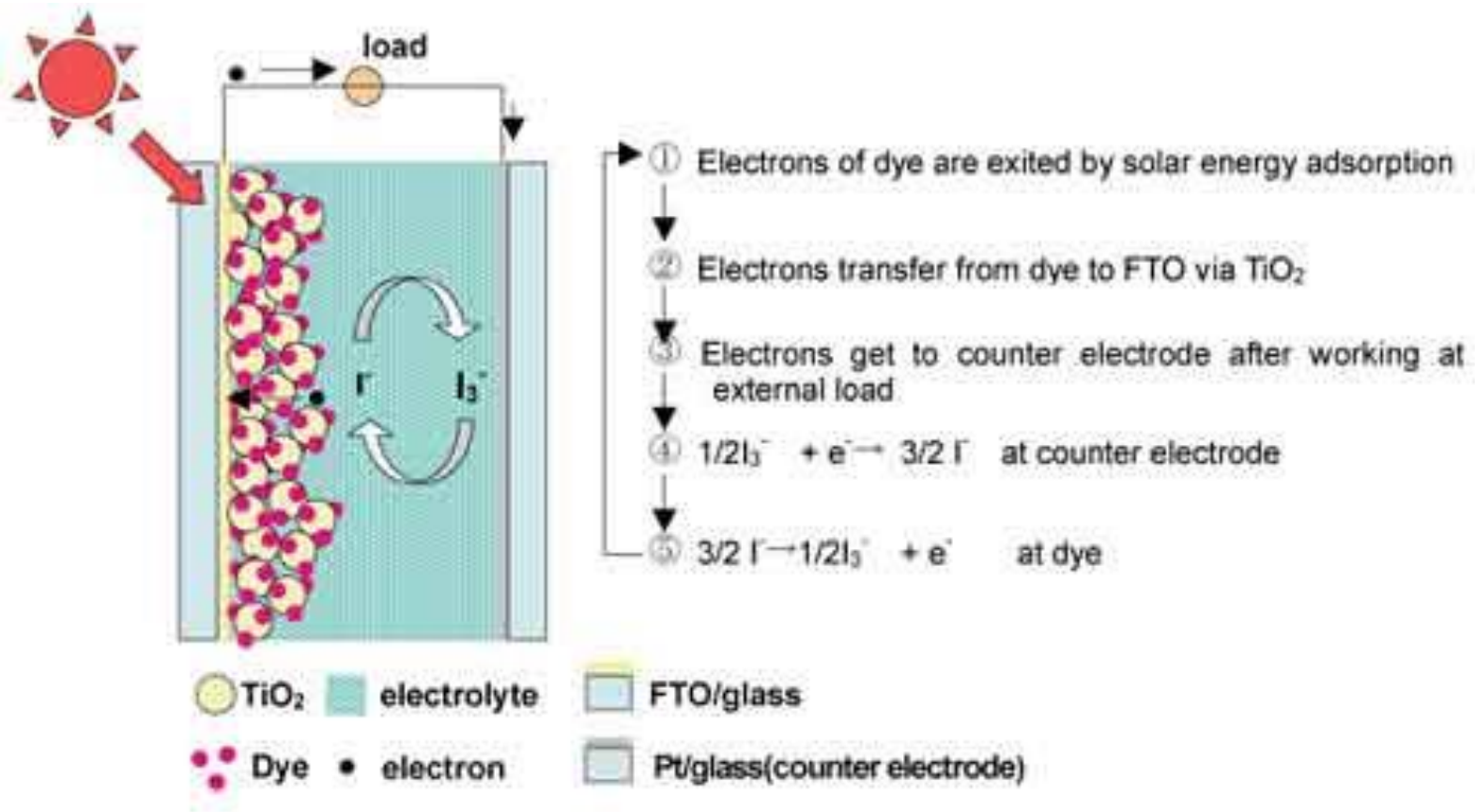
- Dye Sensitized Solar Cells (DSSC) works similarly as a leaf on a plant [3].
- The chlorophyll dye in a leaf absorbs solar energy and converts it into chemical energy (starch).
- The principle of power generation of DSSC is very similar to that of photosynthesis in plant.
- DSSC takes solar energy and converts into electrical energy.
- DSSC often referred as artificial photosynthesis.

Construction of DSSC



'On global energy scenario, dye-sensitized solar cells and the promise of nanotechnology' in Physical Chemistry Chemical Physics, Issue 15, 2014

Mechanism of DSSC



From an online article by Michael Berger, Nanowerk LLC

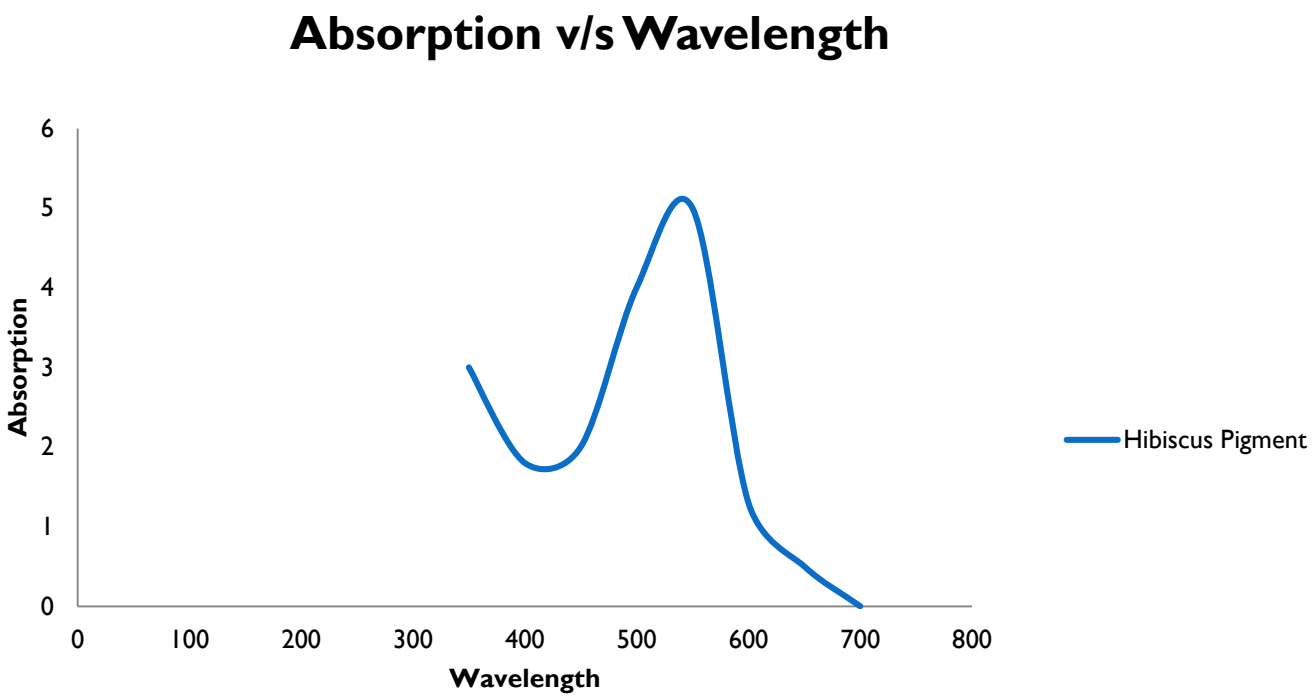
Optical Measurement of Dyes Solutions

[4]

- The optical measurement was made by using Spectrophotometer for dyes prepared (Red Cabbage, Hibiscus, Lemon Leaves and their combinations)

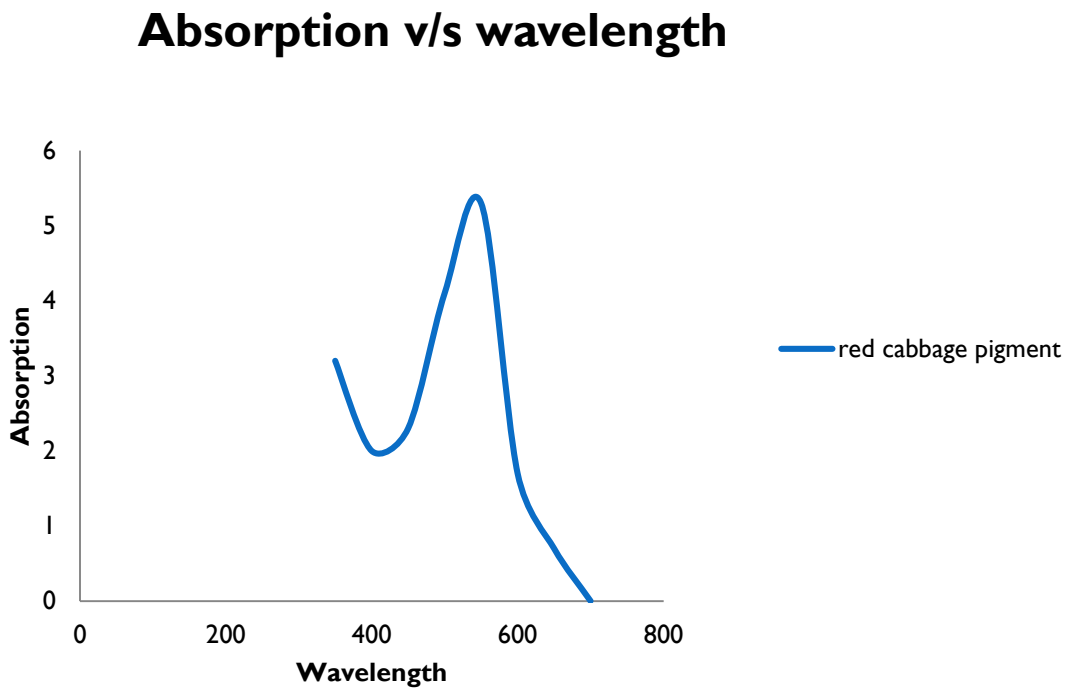
Hibiscus Pigment

- Hibiscus pigment: optical absorbance for hibiscus shows max absorption peak in the visible region at the 560 nm wavelength



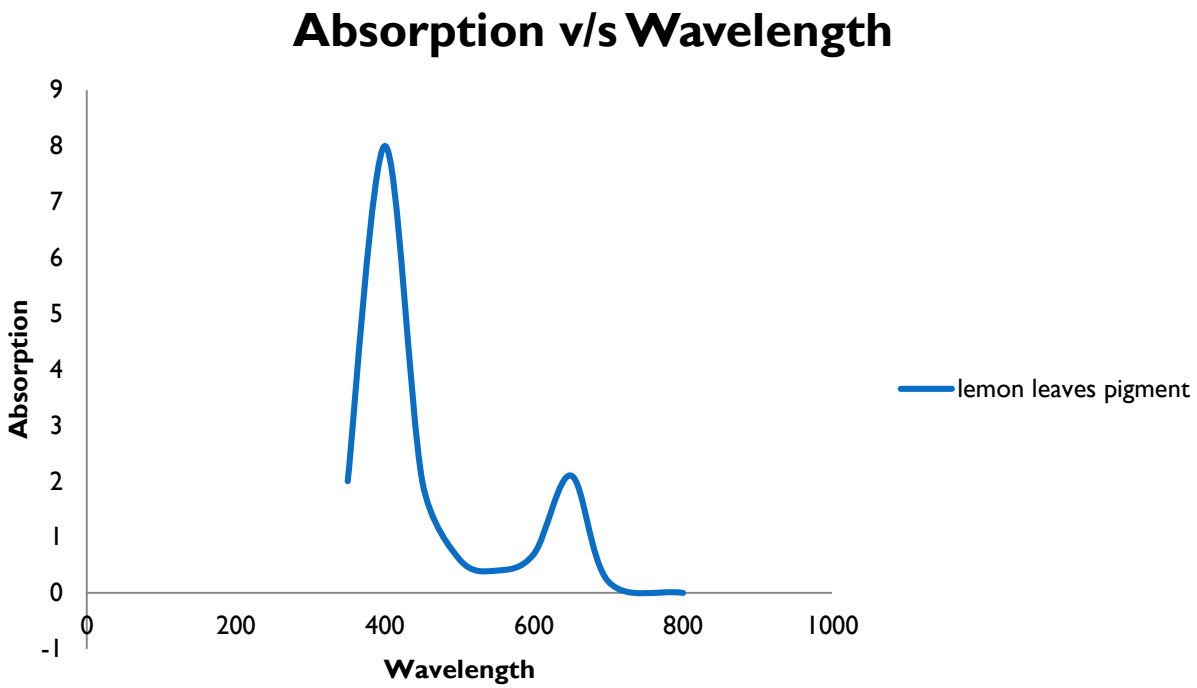
Red Cabbage Pigment

- Red cabbage pigment: optical absorbance for hibiscus shows max absorption peak in the visible region at the 550 nm wavelength



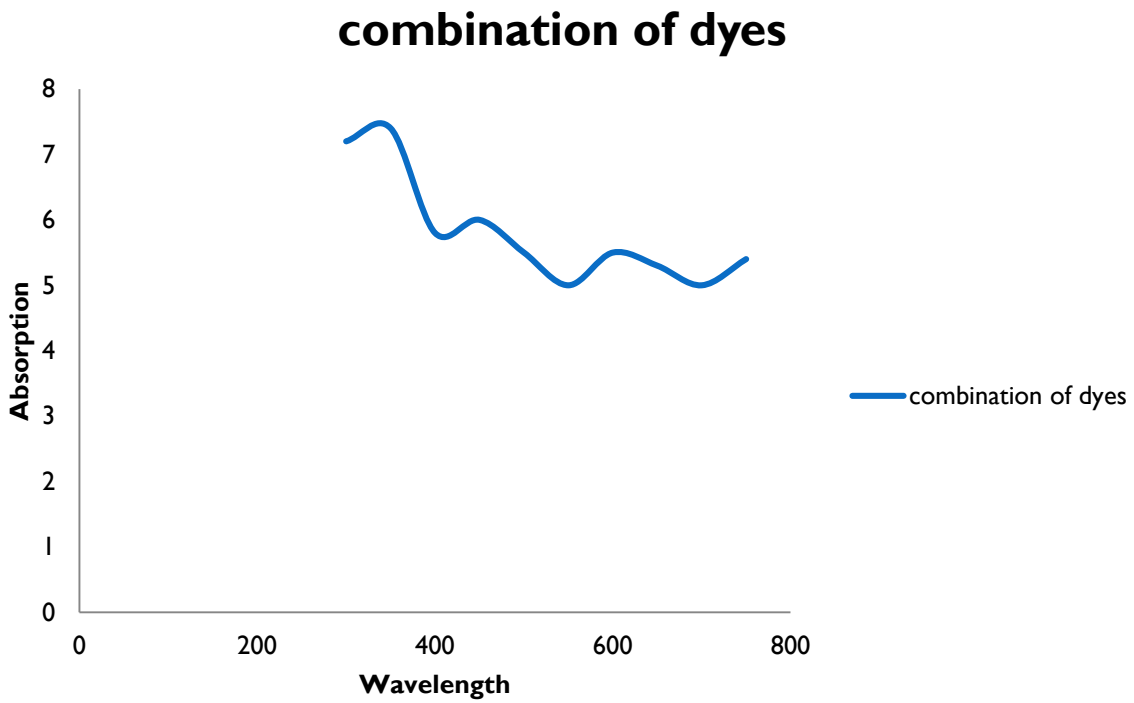
Lemon Leaves Pigment

- Lemon leaves pigment: optical absorbance for hibiscus shows max absorption peak in the visible region at the 400 nm and 650 nm wavelength.



Combination Of Dyes

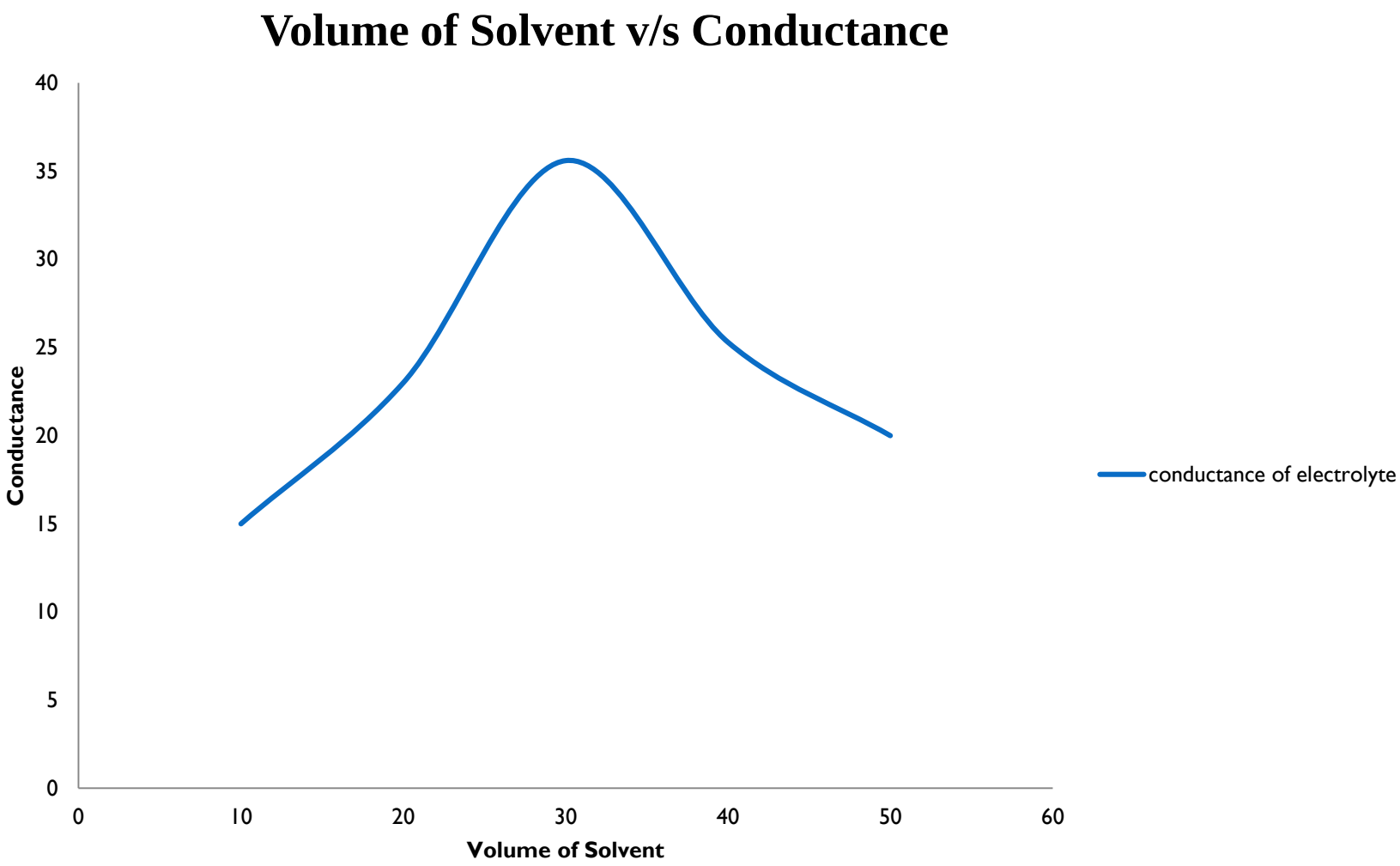
- Combination of dyes: optical absorbance for hibiscus shows max absorption peak in the visible region at the 330nm, 450nm & 600nm wavelength.



Electrolyte Preparation [5]

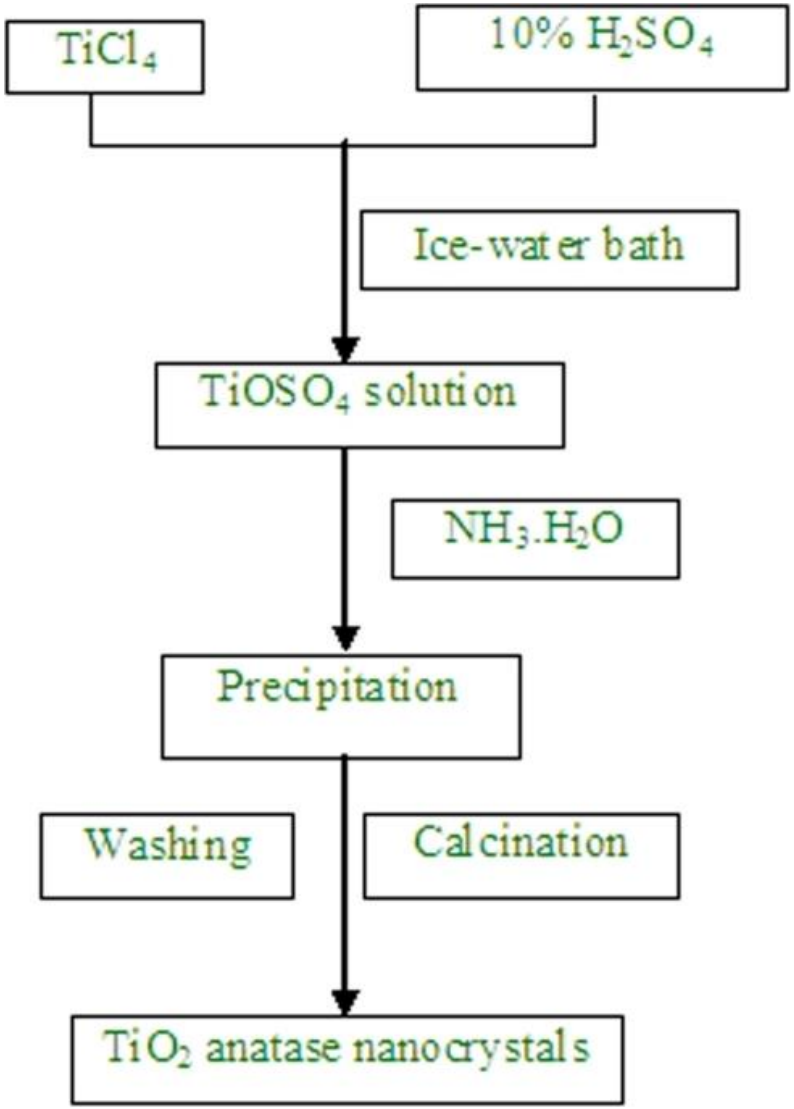
- Add 6 gm of potassium iodide to 30 ml of solvent and stir for 15 minutes. Then add 2 gm of iodine. Stir and store in dark bottle.

Study of Conductance Of Electrolyte



Preparation of TiO2

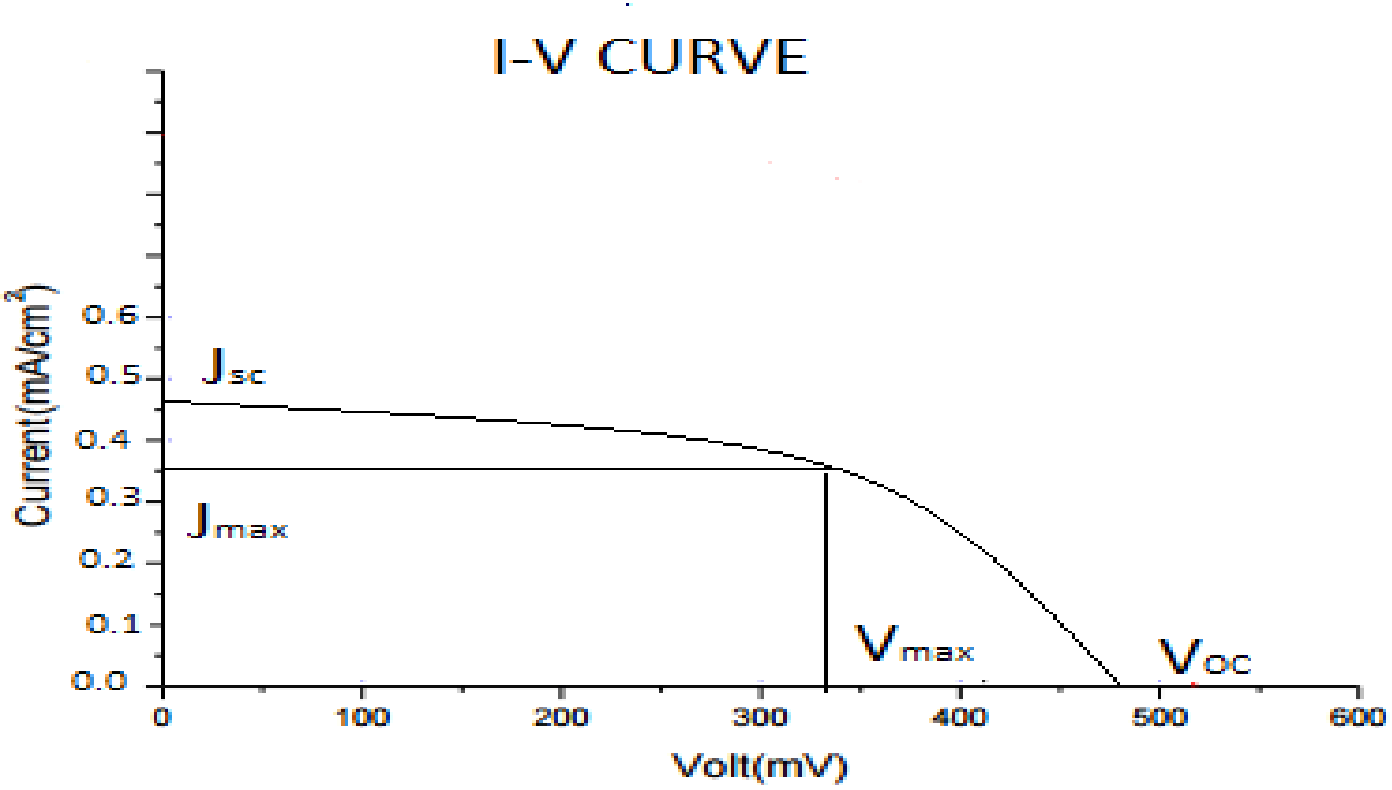
[6]



Experimental Setup for Preparation of TiO_2

CURRENT VOLTAGE CURVE (For Area = 1 sq.cm.)

[7]



Final Results for DSSC

Dyes	Voc (mV)	JSC (mA)	FRICTION FACTOR	EFFICIENCY (%)
HIBISCUS	490	0.45	0.55	1.22
RED CABBAGE	0.70	530	0.78	2.89
LEMON LEAVES	510	0.66	0.54	2.69
COMBINATION	688	1.21	0.73	6.07

SOLAR CONVERSION EFFICIENCY

[8]

The solar conversion efficiency of DSSC can be estimated by :

$$\eta = \frac{JSC \times VOC \times FF}{Pin}$$

$$= \frac{0.45 \times 490 \times 0.52}{100}$$

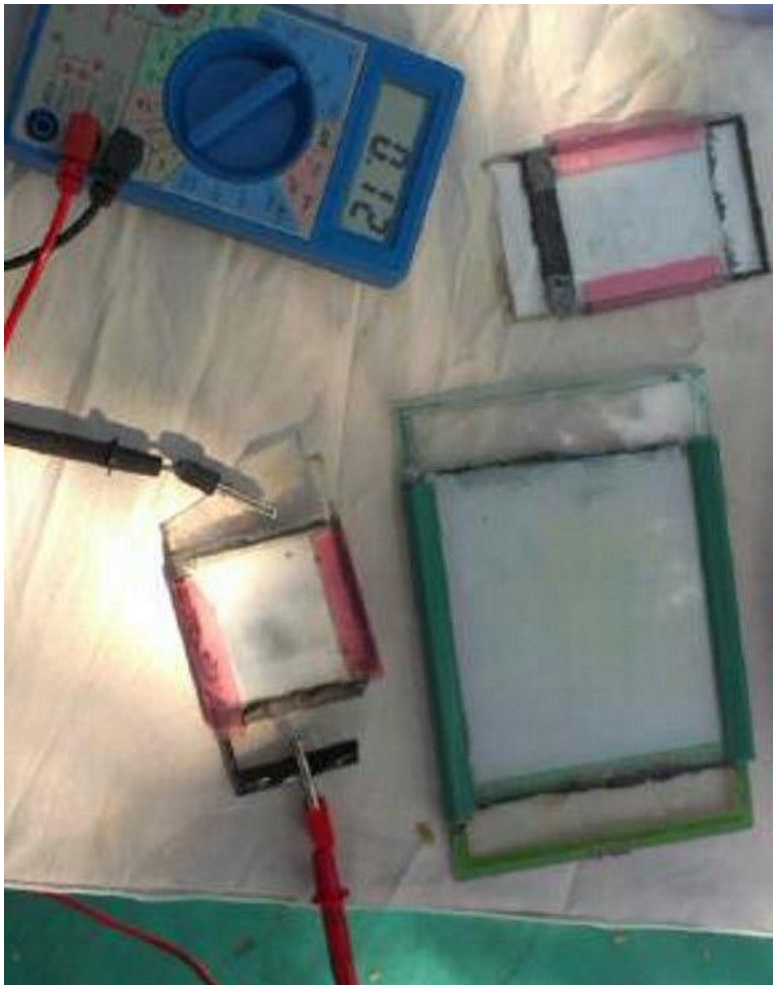
$$= 1.14\%$$

$$FF = \frac{Pmax}{Jsc \times VOC}$$

$$= \frac{0.35 \times 330}{0.45 \times 490}$$

$$= 0.52$$

The Panels



Results Based On Various Water Sources

[9]

PARAMETERS	METHOD	UOM	SCET COLLEGE WATER INPUT	SCET COLLEGE WATER OUTPUT	HOSTEL WATER INPUT	HOSTEL WATER OUT PUT
PH	IS-3025 (PART1)	-	8.1	8.5	8	8.5
CONDUCTIVITY	ASTMD1125-95	µs/cm	508	402	829	664
TURBIDITY	IS-3025 (PART-10)	NTU	0.5	0.05	0.6	0.06
CHLORINE	IS-3025 (PART-32)	ppm	50	4	107	9
TOTAL HARDNESS	IS-3025 (PART-21)	ppm	153	141	180	157
ALKALINITY	IS-3025 (PART-21)	ppm	59	70	68	81
TSS	IS-3025 (PART-17)	ppm	0	0	0	0
TDS	IS-3025 (PART-16)	ppm	288	101	450	158
COD	ALPHA 5220-D	ppm	0	0	0	0
ARSENIC	IS-3025 (PART-13)	ppm	0	0	0	0

Results Based On Various Water Sources [9]

PARAMETERS	METHOD	UOM	RELIANCE REFINERY WATER INPUT	RELIANCE REFINERY OUTPUT	JAMNAGAR WATER INPUT	JAMNAGAR WATER OUTPUT	TAPI WATER INPUT	TAPI WATER OUTPUT
PH	IS-3025 (PART1)	-	7.5	7.8	7.9	8.3	8.0	8.4
CONDUCTIVITY	ASTMD1125-95	µs/cm	28100	16869	366	256	516	361
TURBIDITY	IS-3025 (PART-10)	NTU	20	4	0.7	0.1	0.46	0.05
CHLORINE	IS-3025 (PART-32)	ppm	9000	3125	5	1.2	46	3.5
TOTAL HARDNESS	IS-3025 (PART-21)	ppm	3143	2829	104	91	145	132
ALKALINITY	IS-3025 (PART-21)	ppm	498	593	84	99	61	73
TSS	IS-3025 (PART-17)	ppm	12	4.2	0	0	0	0
TDS	IS-3025 (PART-16)	ppm	18000	15325	220	77	310	109
COD	ALPHA 5220-D	ppm	45	6.75	0	0	0	0
ARSENIC	IS-3025	ppm	0.03	0.002	0	0	0	0

Cost Comparison

[10]

WATER FILTER	COST (Rs)	WATER FILTER	COST (Rs)
Aqusana 3 Stage Under Counter	10819	Eurekha Forbes Aquasure Prime	8244
Water Chef U9000	19584	Kent ACE	19000
Apec Water RO 50	12374	Hindustan Unilever Marvello RO+UV	15633
Kenmore Reverse Osmosis System	10570	Reliant Typify	13990
Pelican Pro 6 Stage RO	21701	Reliant Troops	14990
Multi Pureaqua RO	37308	Reliant Previous	16990
GE Reverse Osmosis Filtration System	6837	Eurekha Forbes Aquaguard Reviva	13990
Aqua Pure Ap RO-5500	24834	TATA Swach	1150
Kinetico Aqua Kinetic	23000	Eurekha Forbes Aquaguard Total SENSA	18990
Hindustan Unilever Pureit Marvella UV+ Cold	14590	Eurekha Forbes Aquaguard Invisipure RO	13500
Our Proposed Water Purification System		**Model for small families** **Scaled up model for 20-25 people (BSF + UV)** **Scaled up model for 20-25 people (BSF Only)**	**1200** **7000** **3500**

Comparison Of Different Water Parameters (% Reduction) [11]

Parameters	Aquasana Water Filter	Kent RO	Merlin RO	Our Water Purifier	Millennium RO System
Water Temperature ^{0}C	10-40	10-40	10-40	10-40	10-40
Chlorine Content (Mg/Lit)	94%	94%	90%	92%	92%
Turbidity (NTU)	94%	94%	89%	95%	95%
TDS (Mg/Lit)	60%	73%	85%	65%	73%
Hardness (Mg/Lit)	66%	66%	72%	65%	65%
Iron	95%	96.3%	93.7%	96%	95%
Arsenic	94%	98.7%	94.6%	99%	98%

Effect against Microbes [12]

The biosand filter has been studied in the field and in labs. It has been shown to remove the following from contaminated water:

- Up to 100% of helminthes (worms)
- Up to 100% of protozoa
- Up to 98.5% of bacteria
- 70-99% of viruses
- Considered as one of the best filters to fight against *E.Coli Bacteria* – the largest cause of diarrhea globally

Scope for Further Development

- We are still working on improving the efficiency of the DSSC Panels and it's designs in order to run the UV Light.

- The pH needs to be reduced. So we are working on some new ways of creating a robust pH-neutralizer.

- We are in talks with several incubators and accelerators regarding seed funding and taking the project forward. We have also started with a geographical survey as to what our exact markets in India are so that a bigger picture can be summed up.

Review

- By using all our techniques, we have managed to get the outlet water quality well under the limits of Indian Standard Specifications for Drinking Water (IS: 10500).

- The use of DSSC in our proposed system makes it self-efficient. The result is a very low cost water purification system which is not only easy to use and maintain but is also highly efficient in quality and looks after the drinking water problems of the masses, especially the people living in rural areas and the third world countries.

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THINK ABOUT
WHAT YOU COULD SAVE
WHEN YOU SAVE WATER.

Questions???

Design Comparison

[10]

Water Filter	Easy-to-change Filters	DIY Installation	Replacement Notifications	Number Of Faucet Options	Width (Inches)	Depth (Inches)	Height (Inches)	Storage Capacity (liter)	Power Required (Watt)
Aqusana 3 Stage Under Counter	Yes	Yes	Yes	3	12	4.25	9	5	25
Water Chef U9000	Yes	Yes	Yes	4	6	8	9	6.7	25
Apec Water RO 50	Yes	Yes	-	1	16	5.25	17.5	4	40
Kenmore Reverse Osmosis System	Yes	Yes	Yes	1	15	16	15	10	60
Pelican Pro 6 Stage RO	Yes	Yes	-	3	12	4.75	14.5	5	30
Multi Pureaqua RO	Yes	-	-	1	15.75	5.25	14.25	-	30
Eco Water ERO 375	Yes	Yes	Yes	5	12.5	4.25	17	8	45
Our Proposed Water Purifier	Yes	Yes	No	1	50	24	32	75	11

Design Comparison

[10]

Water Filter	Easy-to-change Filters	DIY Installation	Replacement Notifications	Number Of Faucet Options	Width (Inches)	Depth (Inches)	Height (Inches)	Storage Capacity (liter)	Power Required (Watt)
Kinetico Aqua Kinetic	Yes	Yes	-	1	15	5	21	6	-
Eurekha Forbes Aquaguard Invisipure RO	Yes	-	Yes	1	290	185	410	5	35
Hindustan Unilever Marvello RO+UV	Yes	Yes	-	1	456	154	567	10	-
Eurekha Forbes Aquasure Prime	Yes	-	Yes	1	281	198	413	4	25
Kent ACE	Yes	-	-	1	380	270	505	7	60
Aqua Pure Ap RO-5500	Yes	Yes	-	1	15	6	15	7	30
Our Proposed Water Purifier	Yes	Yes	No	1	50	24	32	75	11

Design Comparison [10]

Water Filter	Easy-to-change Filters	DIY Installation	Replacement Notifications	Number Of Faucet Options	Width (Inches)	Depth (Inches)	Height (Inches)	Storage Capacity (Liter)	Power Required (Watt)
Reliant Typify	Yes	Yes	Yes	1	300	290	410	9	30
Reliant Troops	Yes	Yes	Yes	1	280	270	395	12	30
Reliant Previous	Yes	Yes	Yes	1	175	325	525	12	30
Kent Grand Plus	Yes	Yes	Yes	1	260	410	520	8	-
Eurekha Forbes Aquaguard Reviva	Yes	-	Yes	1	320	275	410	8	25
TATA Swach	Yes	-	No	1	300	282	572	18	No
Eurekha Forbes Aquaguard Total SENSA	Yes	Yes	Yes	1	344	322	473	9.5	40
Our Proposed Water Purifier	Yes	Yes	No	1	50	24	32	75	11