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Reclamation of Saline Water through Solar Desalinization Process under Arid/Semi-Arid of Thar at Umerkot District, Sindh, Pakistan

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Abstract: *Drinking water is essential necessitate for daily life as there is dearth of water in many parts globally. Water quality ought to be such that it can be used by persons for drinking purpose. There are already plenty of solar units present in the market that can do reclamation process, as the available desalinization solar units clean the water safe to drink In desalination process the removal of salt and other minerals from the water is carried out to make it suitable for human consumption and industrial use. Reverse Osmosis (RO) is the one and only one regularly used domestic filtration system that removes even all the impurities. RO is required if the Total Dissolved Solids (TDS) exceeds a certain value. The main objective of this project is to use the sun as source of energy through solar desalinization technique which cleans water for drinking purpose and installed three or four desalinization solar units at village level that operates on solar power. This study showed that 88 liters saline water provided the maximum drinkable water at the adjustment@6 liters/hr/panel at Arid Zone Research Institute, UmerKot. The performance of desalinization solar units installed at Goth Nawab Ji Dhani (Umerkot) using brackish water having 14.45 dSm^{-1} salts removed the toxic salts through solar desalinization technique and reduced it to 0.15 dSm^{-1}. Water having so minute salts is fit for drinking purpose. This system creates awareness to the local communities.*

Keywords: *RO (Reverse Osmosis), TDS (Total Dissolved Solids), Desalination solar units*

1. Introduction

The total desert land (Tharparkur and Umerkot) is about 05 million hectares out of which 02 million hectares are not cultivable. Agriculture in the desert is entirely dependent on rainfall. The drinkable water is available in patches. Mostly water is brackish in nature. So there is scarcity of good quality of drinkable water in the urban areas as well as remote Thar/desert areas. Solar powered water desalination is increasingly becoming a competitive solution for providing drinking-water in many countries around the world. The desalination of saline water has been documented as one of the most sustainable and fresh water resource substitute. It plays a decisive role in the socio-economic development for many communities and industrial sectors. At present there are over 14,000 desalination plants in function worldwide cleaning several billion gallons of saline water per day. Fifty-seven percent are in the Middle East and Gulf region where large scale conventional heat and power plants are installed. However, since they are operated using fossil fuels, they are becoming expensive to operate and the pollution and greenhouse gas emissions they produce are increasingly recognized as harmful to the environment. Moreover, such plants are not economically viable in remote areas, even in coastal regions where seawater is abundant. Many areas often experience a shortage of fossil fuels and inadequate and unreliable electricity supply. The integration of renewable energy resources in desalination and water purification is becoming more viable as costs of conventional systems increase, commitments to reduce greenhouse gas emissions are implemented and targets for exploiting renewable energy are set. Thus, solar energy could provide a sustainable alternative to drive the desalination plants, especially in countries which lie on the solar belt such as Africa, the Middle East, India, Pakistan and China. Pure water is the basic necessary for all living organism. Now days, the availability of clean water resource is a major issue for mankind. A lack of infrastructure for water storage and distribution is also a factor in the developing world. More than71% of the earth surface is covered with the water, but only 1%

clean drinkable water is available with the international standards (Dev Rahul and Tiwari, 2009).Provision of safe drinking water is a vital for the life and domino effect in socio-economic development. Fresh water resources are rapidly declining due to increase of the population and mismanagement and the emerging climate changes are further accelerating the process of water scarcity. This is a need of the time to use saline water drinkable particularly in the coastal areas which have lowest access to the safe drinking water and ground water is often brackish. The coastal population is prone to a number of health problems because of using perilous water. Distillation is one of many processes that can be used for water purification. This requires an energy input, as heat, solar radiation can be the source of energy. In this process, water is evaporated, thus separating water vapor from dissolved matter, which is condensed as pure water. Unadventurous technologies used for disinfection of unpotable water include ozonation, chlorination, and artificial UV radiation. These technologies are capital intensive, require sophisticated equipment, and demand skilled operators (Acher *et al.*, 1997; Pelizzetti, 1999; U.S. Environmental Protection Agency, 1996).Unhygienic water causes an anticipated 6 to 60 billion cases of gastrointestinal illness annually. Nearly all of these cases occur in rural areas of developing nations where the water supply is polluted with a range of microorganisms, counting viruses, fecal coliforms, and protozoa, and adequate sanitation is unavailable. The need for a low-cost, low-maintenance, and effective disinfection system for the improvement of water quality is high. Boiling, for example, needs about 1 kg of wood/liter of water, and abuse of sodium hypochlorite solution poses a safety hazard (Acra *et al.*, 1990; Bunce, 1991; Ishikawa *et al.*, 1986).

2. Experiment Procedure/ Design

The following are the description of solar powered water desalination system AROCELL solar water purifies Australian technology. It only use sun energy, there are no moving parts, no electronics. It is robust and easy to setup, low maintenance and very low in operating cost because the water purifier only need solar energy. The feed water is supplied by gravity or pressure pump CAROCELL direct solar powered desalination technology, working at ambient temperature, heats the input water causing vapors condensation change precluding all bacteria and pathogens, therefore eliminating all water borne diseases Exposure to ultra violet light and extreme heat from solar energy through the advanced composite panels enhances the germ killing process. CAROCELL's increased efficiency (65% with peak efficiencies above 80%) over other solar distillation products (30 – 40%) is a combination of the proprietary materials used to dramatically increase the temperature of the feed water on the solar collector which enhances the evaporation / condensation processes inside the panel. Additionally, this sophisticated geometrical design has easy maintenance, optimum performance and a self-controlling natural convection loop enabling widely superior energy recovery.

Alignment of poles for solar desalination mounted on pole

Zero level of poles installation for desalination mounted on pole

Train the farmers for operation and maintenance of solar desalination system

Working of Solar Desalination System in Field Areas of Umerkot

Under this study 08 solar desalination units were installed i.e.2 solar desalination units at Goth Nawab Ji Dhani, Umer Kot, 2 solar desalination units at Goth Havalley Rehmatullah , Umer Kot and 4 solar desalination units at AZRI, Umerkot.

3. Results And Discussions

The purification of saline water into drinkable water depends upon the intake saline water capacity of each desalinization solar unit. During experimentation it was observed that intake water (saline water) should be adjusted @6 liters/hr/panel for the better working of the solar system. Data indicated in table-

1 showed that 88 liters saline water provided the maximum drinkable water at the adjustment@6 liters/hr/panel at Arid Zone Research Institute, UmerKot. Solar units installed at GothNawab ji Dhani (Umerkot) also performed well to clean the saline water. Similar results were also determined at third location (Goth Haveli Rehmatullah, Umerkot). This table showed the better performance of the desalinization solar units if intake water adjustment was done @6 liters/hr/panel).Solar radiation removes a wide range of organic chemicals and pathogenic organisms by direct exposure, is relatively economical, and avoids cohort of harmful byproducts of chemically driven technologies (Calkins *et al.*, 1976). More prominently, the economics of the process are approximately capacity self-reliant (Gloyna, 1971).The reduction in intensity varies with wavelength; for wavelengths ranging from 200 to 400 nm the reduction in intensity does not exceed 5%/m of water depth; however, it rises as high as 40%/m for longer wavelengths (Acra *et al.*, 1990).Approximately 70% underground water is brackish/ saline. This water is unfit for drinking. The removal of excess salts from brackish water is the utmost requisite for the supply of drinkable water at the remote areas having dense saline water. Water quality is the main issues to save the whole humanity from epidemic diseases. Clean drinkable water is the basic right of the whole world. So this experiment was launched at three locations in District Umerkot represented areas of Thal/ desert in Sindh province of Pakistan. Electrical conductivity is the main criteria to evaluate the water fitness for drinking purpose. Data presented in table2 showed the performance of desalinization solar units installed. Brackish water having 14.45 dSm^{-1} salts at Goth Nawab Ji Dhani (Umerkot) removed the toxic salts through solar desalinization technique and reduced it to 0.15 dSm^{-1}. Water having so minute salts is fit for drinking purpose. Similar results were also indicated from other two locations. Water analysis report issued by PCSWR shoed the fitness of the treated water through the utilization of this solar desalinization process at Umerkot sites. Utilization of sunlight for the reclamation of brackish water through solar desalinization is the friendly environment, most economical and easily installed with local training. Maintenance cost of these solar units is also very minute. The use of solar irradiation for treatment of chemically and biologically contaminated water is not a new trend (Calkins *et al.*, 1976: Conroy *et al.*, 1996; Davies-Colley *et al.*, 1994; Malik *et al.,* 1982; Safapour and Metcalf, 1999; Sinton *et al.*, 1999, 2002).

Four unit of solar desalination installed at AZRI, Umerkot, Sindh

Two unit of solar desalination at Havelli Rahmatullah, Umerkot, Sindh

Two unit of solar desalination at Goth Nawab Ji Dhani, Umerkot, Sindh

Water analysis report of Umerkot installed desalination units

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Science & Technology, Government of Pakistan
Khiaban-e-Johar, H-8/1, Islamabad
www.pcrwr.gov.pk

WATER QUALITY TEST REPORT (CHEMICAL ANALYSIS)

Report Serial No	Chem-62	Total No. of Pages	01
Client Name & Address	AZRI, Umerkot, C/O Dr. Ashraf Sab, Chairman, PCRWR, Islamabad.		
Sampling Date	----	Sampling Time	----
NWQL Sample Code.	INT-CL-62-15	Client Code	Bored Water
Temperature of sample at receipt °C	17 °C	Sample Receipt Date	11-5-15
Date (s) of Analysis	11-5-15 to 13-5-15	Reporting Date	14-5-15

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA/NSDWQ, 2010)	Results
1.	Color	-	-	Sensory evaluation	Colorless	Colorless
2.	Electrical Conductivity	(µS/cm)	0.3	APHA, 21st Edition	NGVS	49 0.049 ds/m
3.	pH	-	0.03	APHA, 21st Edition	6.5-8.5	8.00
4.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	BDL
5.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	15
6.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	15
7.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	5
8.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	BDL
9.	Chloride	ppm	2.0	APHA, 21st Edition	250	3
10.	Hardness	ppm	5.0	APHA, 21st Edition	500	20
11.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	2
12.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	BDL
13.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	3
14.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	2
15.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	1
16.	TDS	ppm	-	APHA, 21st Edition	1000	27

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA**: American Public Health Association, **BDL:** Below Detection Limit, **QC**: Quality Control **CSS**: Customer Service Section, **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards, **NSDWQ:** National Standard for Drinking Water Quality

Quality of Water	Safe ☐	Unsafe ☐
Quality of Wastewater	Safe ☐	Unsafe ☐

Terms & Conditions:

- Test results in this report relate only to the test item/sample submitted and tested.
- The test report shall not be reproduced except in full, without written approval of NWQL-PCRWR
- Water Quality Parameters exceeding the WHO Drinking Water Guideline values (Guidelines for Drinking-Water Quality, third editions, 2004) National Environmental Quality Standards (1999) and Pakistan Standard Quality Control Authority/National Standard for Drinking Water Quality (PAKEPA, 2010) are highlighted.

Prepared by	Abdul Jabbar	Tech. Manager (Chem.)	Shazia Ghaffar
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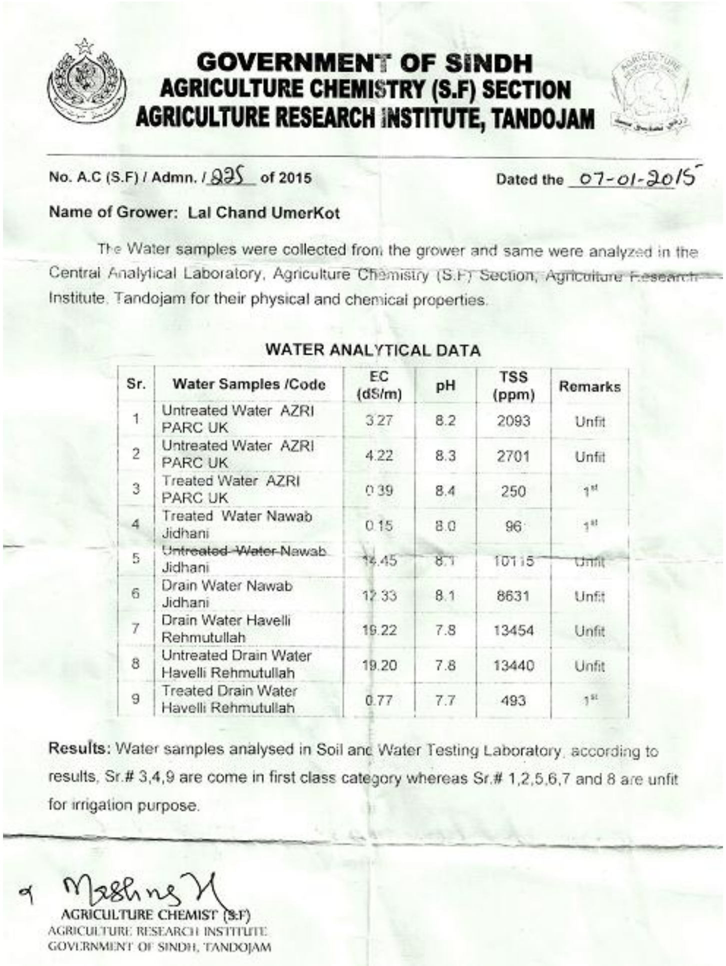

GOVERNMENT OF SINDH
AGRICULTURE CHEMISTRY (S.F) SECTION
AGRICULTURE RESEARCH INSTITUTE, TANDOJAM

No. A.C (S.F) / Admn. / 225 of 2015 Dated the 07-01-2015

Name of Grower: Lal Chand UmerKot

The Water samples were collected from the grower and same were analyzed in the Central Analytical Laboratory, Agriculture Chemistry (S.F) Section, Agriculture Research Institute, Tandojam for their physical and chemical properties.

WATER ANALYTICAL DATA

Sr.	Water Samples /Code	EC (dS/m)	pH	TSS (ppm)	Remarks
1	Untreated Water AZRI PARC UK	3.27	8.2	2093	Unfit
2	Untreated Water AZRI PARC UK	4.22	8.3	2701	Unfit
3	Treated Water AZRI PARC UK	0.39	8.4	250	1st
4	Treated Water Nawab Jidhani	0.15	8.0	96	1st
5	~~Untreated Water Nawab~~ Jidhani	14.45	8.1	10115	Unfit
6	Drain Water Nawab Jidhani	12.33	8.1	8631	Unfit
7	Drain Water Havelli Rehmutullah	19.22	7.8	13454	Unfit
8	Untreated Drain Water Havelli Rehmutullah	19.20	7.8	13440	Unfit
9	Treated Drain Water Havelli Rehmutullah	0.77	7.7	493	1st

Results: Water samples analysed in Soil and Water Testing Laboratory, according to results, Sr.# 3,4,9 are come in first class category whereas Sr.# 1,2,5,6,7 and 8 are unfit for irrigation purpose.

AGRICULTURE CHEMIST (S.F)
AGRICULTURE RESEARCH INSTITUTE
GOVERNMENT OF SINDH, TANDOJAM

Table1. *Performance Evaluation of 8 Desalinization units at Multiple locations of Umerkot District, Sindh, Pakistan*

Latitude = 25°21'41.2"N , Longitude = 69°44'36.91" E or 25.361444 and 69.743586									
Month	Temp.(C°)		Ave. Discharge (lh^{-1})			Solar Panels	Solar Irradiation (KWh/m^2)	Volume of treated water day^{-1}(8hrs)
January	Max.	Min.	Untreated	Treated	Drained	Nos	Umerkot	Liters
Arid Zone Research Institute, Umerkot.	25.4	18.5	88(24) 80(24) 72(24) 64(24)	7 5 4 6	80 72 60 58	4 4 4 4	200 200 200 200	56 40 32 48
GothNawab ji Dhani.	25.4	18.5	36(12)	3	-	2	200	24
Goth Haveli Rehmatullah.	25.4	18.5	40(12)	4.28	18	2	200	34

The discharge of intake water (untreated) should be adjusted @6 liters/hr/panel

Table2. *Drinking water Quality Evaluation of Desalinization units at Multiple locations of Umerkot District, Sindh, Pakistan (Latitude = 25°21'41.2"N, Longitude = 69°44'36.91"E)*

Brackishwater with source	Untreated Water			Treated Water			Drained Water		
	ECw (dSm^{-1})	TSS(ppm)	pH	ECw (dSm^{-1})	TSS (ppm)	pH	ECw(dSm^{-1})	TSS (ppm)	pH
Goth Nawab Ji Dhani	14.45	10,115	8.1	0.15	96	8.0	12.33	8631	8.1
GothHaveli Rehmatullah	19.20	13,440	7.8	0.17	49	7.7	19.22	13,454	7.8
AZRI, UmerKot	3.27	2093	8.2	0.39	250	8.4	4.22	2701	8.3

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