International Journal of ChemTech Research
CODEN(USA): IJCRGG ISSN : 0974-4290
Vol.5, No.3, pp 1195-1204, April-June 2013

IPACT-2013[14th – 15th March 2013]
National Conference on Industrial Pollution And Control Technology-2013

Utilization Of Solar Energy For The Treatment Of Sugar And Distilleries Effluent

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Abstract: The investigator has made an attempt to find the impact of sugar and distilleries industry effluent in the environment. India is the largest country producing sugar and alcohol in the world and per capita consumption of sugar in the country is 13.4 k.g. The investigator observed that the solar evaporation tank made of black tank function more effectively during summer with very high evaporation rate and moderate evaporation in other seasons. The investigator found that the during the normal operation, the colour of the sugar and distilleries effluent varies and becomes clear after treatment with alum, which favors the penetration of solar thermal energy easily. Hence the efficiency of the solar evaporation tank increases than the normal cement slab tank. Because of the pollution created by the effluents from the sugar and distilleries industry, it is essential to treat the effluent by proper treatment process in the primary treatment stage. The investigator recommends to all sugar and distilleries industry to use black kadappa stone for constructing the solar evaporation tank in order to recover the salts which causes pollution in water resources. The continuous use of the solar evaporation tank can certainly reduce the volume of effluent discharged from the treatment plants. The advantage of utilizing the black body natural kadappa tanks for evaporation is very faster and it can absorb very high degree of solar radiation which is converted into thermal energy and it is directly converted into heat energy. Heat energy is utilized for the evaporation of sugar and distilleries effluent.

The investigator observed that the solar evaporation tank made of black body tank function more effectively during summer with very high evaporation rate and moderately in other seasons. It is observed that the sugar and distilleries effluent treatment by solar evaporation tank will be eco friendly, economical, simple and easy for adoption in sugar and distilleries industry in Tamil Nadu. The effluent from sugar and distilleries can cause harmful effects to the environment. Hence the use of black body stone can prevent the water pollution to the maximum level. Thermal energy is directly used for the evaporation of the high volume of sugar and distilleries effluent which causes pollution of ground water and surface water. The solar evaporation tank is blessed with the principle of black body surface which can absorb more solar radiation and more effective than ordinary cement slab tank. The black natural kadappa slabs obtained from the earth is used for construction of solar evaporation tank in stepwise position like primary, secondary, and tertiary treatment methods.

Key Words: Waste water treatment, solar evaporation, distilleries effluent, kadappa tanks.

Introduction

The development of solar technologies and an increased understanding of the use of black body stone in the effluent evaporation process[2,3,5] are providing both economical and environmental benefits.[3,6,] All countries in the world receive solar energy. The amount varies from a few hundred hours per year as in the northern countries and the lower part of South America to four thousands hours per year. In the case in most of the Arabian Peninsula and the Sahara desert. When the radiation strikes a solid or liquid it is absorbed and transformed into heat energy. The materials become warmer and stores the heat conducts it to surroundings materials. The absorber plate is usually made of copper, aluminum, steel or another suitable material and is usually coated with black paint. Applications of Solar Energy included, heating of building, cooling of buildings, Solar Water heating and solar heating industrial process and solar drying of agricultural products.[3,4,5] Solar water heater system can meet the low and medium temperature process. Heat requirement like hot water up to 90^{o}c, hot air up to 110^{o}c and low-pressure steam up to 140^{o}c. These are especially useful in engineering, textile, chemicals, pharmaceutical, food processing, sugar and distilleries, diary, dye [1,2,3,4,5] and other Industries. Solar energy could be used for preheating water up to 50-60°c with further heating of process steam to 90°c and above being done in boiler. Solar evaporation is historical and traditional.

Scope, Objectives And Need For The Present Investigation

It is very clear that the environmental pollution is considered as the unfavorable change of water, air, soil, and land. The principal pathway by which chemical pollutants enter in to environment in sugar and distilleries industry is through water discharged from the sugar and distilleries industrial sources. The sugar and distilleries processing effluent in sugar and distilleries industry contains large amount of chemicals which is used for manufacture of sugar and alcohol. The effluent from sugar and distilleries industry having high TDS created a new problem of surface and ground water pollution. The pollution level of the water resources proved to be a threat to the human environmental conditions and damage the environmental conditions and damage also the ecological processes that sustain the production of food. One fine morning people will not be able to get good quality drinking water from the river, wells and water resources due to continuous discharge of sugar and distilleries industry effluent in to the river. Therefore the disposal of effluent from sugar and distilleries industry is becoming a universal problem now. Although the different effluent treatment viz; primary treatment, secondary treatment, tertiary treatment are available but none found to be suitable due to non-availability of man power, cost factor, working difficulty, efficiency and skilled person required for handling the toxic effluents. To overcome the inconvenience, the solar evaporation tank (made up of kadapa stone) employed for the evaporation and recovery of dissolved substance and suspended matter from the sugar and distilleries effluent. Most of the energy received from the sun comes in the form of light, a short wave radiation, not all of which is visible to human eye. When this radiation strikes a black surface it is absorbed better rather than reflect and thus become more heat and conducts heat energy to sugar and distilleries industry effluent at low temperature. This increase the temperature of sugar and distilleries industry effluent from 40^{0}c to 80^{0}c which can improve the evaporation of the effluent having very high TDS. In this project the solar energy shows promise of becoming a dependable heat energy source without new requirement of a highly technical and specialized nature for its wide spread utilization. In addition, there appear to be no significant polluting effects from its use.

Objective Of The Present Investigation

To construct a suitable natural black kadappa stone tank for the evaporation of total dissolved salts, from the sugar and distilleries industry effluent, during the primary treatment process.

- To study the thermal performance of natural black surface solar evaporation tank for the evaporation of sugar and distilleries industrial effluent.
- To study the evaporation potential of the solar evaporation tank for the evaporation process of sugar and distilleries industry effluent.
- To create awareness about the utilizing of black body natural stone for the evaporation of sugar and distilleries industry effluent in order to prevent the dissolved chemicals this can cause ground water and surface water pollution.

- To suggest to the sugar and distilleries industry about the use of black body evaporation tank for the effective, evaporation of the effluent in a shorter period.

Materials And Methods

In Theni district there is one sugar and distilleries industry producing sugar and alcohol from the sugar and distilleries industry. Large volumes of effluent are discharged, indiscriminately into open land, ponds, lake and finally water resources. Hence the present study is undertaken to evaporate the complex sugar and distilleries industry effluent using black body kadappa stone tank for the construction of evaporation tanks. The kadappa tanks can absorb solar radiation readily and evaporate the polluted effluent from sugar and distilleries industry at a faster rate compared to an ordinary cement tanks.

Details Of The Black Body Kadappa Tanks

The black body solar evaporation tank is fabricated with kadappa stone having depth of 20cm and area of 1600cm^2 in stepwise and slanting positions for easy transfer. The outlet pipe from Tank-I is located near the upper part of the Tank-II. Likewise the outlet pipe from Tank-II is located near the upper part of the Tank-III. These three Tanks are placed in the east-west direction (as shown in the photograph). The three Tanks are kept in the open sunlight for the absorption of solar energy in the stepwise position. The solar energy is converted in thermal energ**y.**

Materials

Black Kadappa stone is the material for the construction of the solar evaporation tank. Durability of black kadappa stone and high absorptive for solar radiation is greater than cement concrete tanks. The combined sugar and distilleries industry effluent with high TDS at the primary stage are taken for the treatment in Tank-I for alum treatment.

Preliminary Treatment Procedure

Coagulation

The coagulation normally used is polyelectrolyte and alum. The usual dose of polyelectrolyte and alum solution for this purpose is about 20mg/liter. Dosing of alum improves clarity in the Tank. It coagulates the suspended impurities. All the suspended impurities in the sugar and distilleries effluent will settle at the bottom. Polyelectrolyte is used in advanced waste treatment. The usual does for this purpose is about 0.1 to 0.25 mg/liter. The polyelectrolyte is long chain compounds having positive or negative active sites waiting for the opposite charge ions. It can be used for coagulating the effluents and sewage water. Entering the tank is about 14% of the total incoming solar radiation and losses to ground is about 2% and losses to atmosphere is about 24%. The losses to atmosphere include scattering, reflection by air molecules, dust and clouds, absorption by clouds, ozone etc.

Principle Of Flocculation

Flocculation increases the collision of coagulated solids so that they agglomerate to form settle able or filterable solids. It is accomplished by increasing the velocity gradients in the coagulated liquid. Flocculate detention time is 15-60 minutes.

Absorption Of Solar Radiation In The Black Body Tank

After the primary treatment of sugar and distilleries effluents with polyelectrolyte and alum in Tank-I the solar radiation reaches the effluent surface in the black solar evaporation Tank-II when the solar radiation strikes the horizontal effluent surface, part of radiation reaches the surface is reflected and the rest entering the Tank is attenuated throughout the depth. The useful heat to the Tank is about 14% of the total incoming solar radiation. Losses to ground are about 2% and losses to atmosphere about24%. These losses to atmosphere include scattering, reflection by air molecules, dust and clouds, absorption by clouds, ozone etc.

Principle Involved In The Operation Of The Black Surface Solar Evaporation Tank

A solar evaporation tank is a black kadappa stone tank, which contains the sugar and distilleries effluents. The solar radiation transmitted through the effluent to the blackened bottom where it is absorbed more; in turn, the water adjacent to the bottom is heated.

A natural buoyancy force causes the heated layers of water to rise, as it becomes less dense. Once it reaches the surface, the water loses its heat to the air through convention or evaporates taking heat with it. The colder water, which is heavier, moves down to replace the warm water, creating a natural convective circulation that mixes the water and dissipates the heat.

Experiment-I

Measurement of the temperature, depth and total dissolved solids

10 liters of sugar and distilleries effluent were taken for the evaporation in Tank-I

In the beginning 10 liters of sugar and distilleries industry effluents were taken in Tank-I. The depth of untreated sugar and distilleries industry effluent in Tank-I was measured with the help of a scale. After the treatment of effluent with alum and polyelectrolyte, a period of 2 hours is required for the settlement of effluent in Tank-I. The treated effluent in Tank–I is allowed to flow in to the Tank-II. The depth of pre-treated effluent in Tank-II was noted. After that it was separated into equal depth Tank-II and Tank-III with the help of measuring scale. The amount of total dissolved solids (TDS) present in the sugar and distilleries processing effluent before and after the treatment with alum and polyelectrolyte was found by using TDS meter. After the separate of treated effluent equally in Tank-II and Tank-III the effluent is exposed to solar radiation. The temperature of the pre-treated effluent at 10.00 am in Tank-I and Tank-II are measured.

The Tank-II and Tank-III is exposed to solar radiation. The temperature of treated effluent at 10.00 A.M in Tank-II is measured with the help of thermometer and then for 1 hour time interval. Again the depth, TDS and temperature of pre –treated effluent in Tank-II and Tank-III was noted. This process continued up to 5.00 pm. The same procedure continued for 6 days for the recovery of the total solids and suspended matter from the effluent. The recovered chemicals in Tank-II and Tank-III are stored in polythene bags, for recycling.

Experiment-II

20 Liters of effluent were taken for the evaporations in black kadappa Tank

In the beginning 20 liters of effluents were taken in Tank-I. The depth of untreated sugar and distilleries industry effluent in Tank-I as measured with the help of a measuring scale. After the treatment of effluent with alum and polyelectrolyte.

The water in Tank –I is allowed to flow in to the Tank-II. The depth of treated effluent in Tank-II was noted. After that it was separated into equal depth Tank-II and Tank-III with the help of measuring scale. The amount of total dissolved solids (TDS) present in the effluent before and after the treatment with alum and polyelectrolyte was found by using TDS meter. After the separation of pre-treated effluent equally in Tank-II and Tank-III. The Tank-II and Tank-III is exposed to solar radiation. The temperature of Tank-II and Tank-III are measured at 10.00 am with the help of thermometer and then for 1 hr. time interval. Again the depth, TDS and temperature of pre –treated effluent in Tank-II and Tank-III was noted .this process continued up to 4.30pm. The same procedure continued to 10 days for the recovery of the total solids and suspended matter from the effluent. The recovered salts in Tank-II and Tank-III are stored in polythene bags.

Results And Discussion

The water quality for drinking and irrigation depends upon the total dissolved constituents. The dissolved ions are prime importance in determining the water quality for drinking and irrigation purpose. The reason may be that various chemical ions can move much faster into the ground and can seep through the sandy soil in to the ground water and surface water which causes pollution. In general these sugar and distilleries effluent ions can cause high degree of water pollution in the water resources. Hence TDS are dominated in the effluents which enter into the water resources like ponds, lake and river. In order to control the sugar and distilleries effluent problems, the black surface solar evaporation Tank has been fabricated using KADAPPA stone here, black surface of kadappa stone Tank enhances the absorption of solar radiation for evaporation. It prevents the dissolved salts from contaminating the water resources and the soil, directly without any pre-treatment. The results obtained during solar evaporation process using black kadappa tanks are presented and discussed below.

Experiment-I

Results for the evaporation of 10 litres of sugar and distilleries industry effluent

Solar evaporation of the sugar and distilleries effluent on the 1st day of the experiment

NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		35		3.4		16200	
2	11		37		3.3		16500	
3	12:00 P.M		39		3.0		17300	
4	1		43		2.8		17700	
5	2		41		2.7		18400	
6	3		33		2.5		18500	
7	4		32		2.4		18600	

Solar evaporation of the sugar and distilleries effluent on the 2nd day of the experiment

NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		34		2.2		19200	
2	11		37		2.1		19500	
3	12:00 P.M		39		2.0		19700	
4	1		42		1.95		20100	
5	2		40		1.85		20600	
6	3		35		1.71		20800	
7	4		32		1.70		20900	

Solar evaporation of the sugar and distilleries effluent on the 3rd day of the experiment

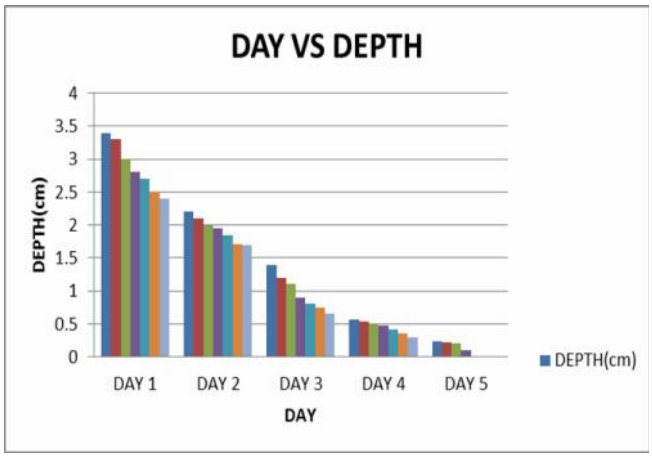
NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		33		1.4		21400	
2	11		38		1.2		22600	
3	12:00 P.M		40		1.1		23500	
4	1		41		0.9		24600	
5	2		39		0.8		25300	
6	3		34		0.75		26100	
7	4		31		0.65		27300	

Solar evaporation of the sugar and distilleries effluent on the 4th day of the experiment

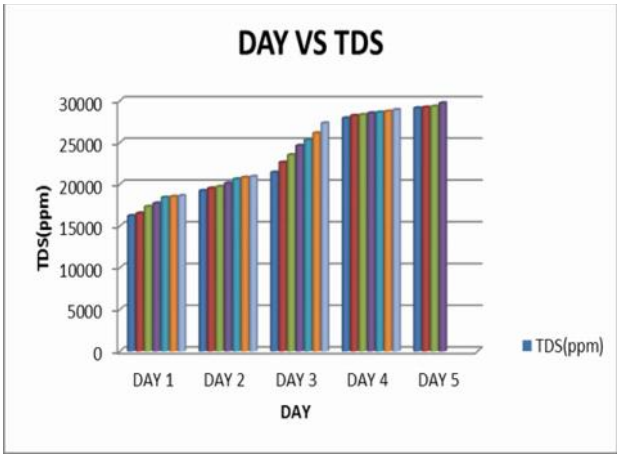
NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		35		0.57		27900	
2	11		38		0.54		28200	
3	12:00 P.M		40		0.50		28300	
4	1		43		0.47		28500	
5	2		41		0.42		28600	
6	3		36		0.35		28700	
7	4		31		0.30		28900	

Solar evaporation of the sugar and distilleries effluent on the 5th day of the experiment

NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		35		0.24		29100	
2	11		37		0.22		29200	
3	12:00 P.M		39		0.20		29300	
4	1		40		0.10		29700	
5	2		-		**Completely Evaporated**			



Depth of the Tank at various days (10L)



TDS of the Tank at various days (10L)

Interpretation Of The Result

From the data in the above tables (for 10 litres) of sugar and distilleries effluent depending upon the value of temperature; the evaporation of treated effluent in TANK-II and TANK-III varies. It certainly causes the decreases in the depth of the treated effluent in TANK-II and TANK-III to a greater extent or lesser corresponding to the effluent in TANK-II and TANK-III. The TDS increases and this can be observed from the tables.

Here, the absorbing surface that is the black surface is used. Hence the black body is a good radiator , the heat is transferred by conduction to the effluent in Tanks .as, the temperature of the effluent rises, the greater is the kinetic energy of the molecules and hence the faster is the evaporation of the effluent and the volume of the effluent decreases and finally it becomes zero volume.

Temperature Of The Sugar And Distilleries Industry Effluent In The Black Evaporation Tank

The higher the temperature of the liquid, the grater is the evaporation rate of the molecules. The rate of evaporation increases with the rise in temperature of the effluent.

The Atmospheric Pressure

The rate of evaporation is inversely proportional to the atmospheric pressure. It has been found experimentally that low atmosphere pressure increases the rate of evaporation.

Extension Of Free Surface Of The Sugar And Distilleries Industry Effluent

The large area of the free surface of the effluent, exposed to the atmosphere, increases the rate of evaporation.

Experiment-II

Result for the evaporation of 20 litres of sugar and distilleries industry effluents.

Solar evaporation of the sugar and distilleries effluent on the 1st day of the experiment

NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		37		5.9		16700	
2	11		38		5.7		16850	
3	12:00 P.M		40		5.5		16940	
4	1		41		5.3		17300	
5	2		40		5.2		17500	
6	3		37		5.1		17800	
7	4		35		5.0		17950	

Solar evaporation of the sugar and distilleries effluent on the 2nd day of the experiment

NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		37		4.7		18500	
2	11		38		4.6		18700	
3	12:00 P.M		42		4.5		19100	
4	1		45		4.3		19500	
5	2		39		4.2		19700	
6	3		38		4.1		19800	
7	4		34		4.0		20200	

Solar evaporation of the sugar and distilleries effluent on the 3rd day of the experiment

NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		37		3.8		20400	
2	11		40		3.7		20500	
3	12:00 P.M		41		3.5		20600	
4	1		43		3.4		20700	
5	2		39		3.3		20800	
6	3		38		3.25		20900	
7	4		35		3.1		2100	

Solar evaporation of the sugar and distilleries effluent on the 4th day of the experiment

NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		30		2.9		21200	
2	11		35		2.9		21400	
3	12:00 P.M		36		2.8		21600	
4	1		38		2.7		21800	
5	2		34		2.65		21900	
6	3		32		2.6		22100	
7	4		31		2.5		22200	

Solar evaporation of the sugar and distilleries effluent on the 5th day of the experiment

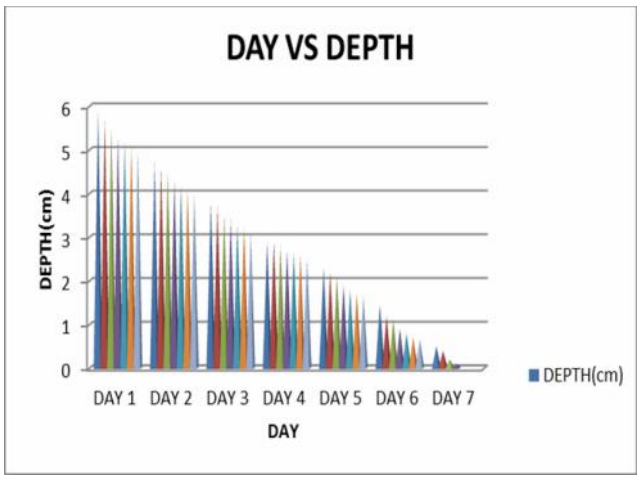
NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		40		2.3		22600	
2	11		41		2.2		22700	
3	12:00 P.M		42		2.1		22800	
4	1		45		1.9		23150	
5	2		38		1.8		23300	
6	3		37		1.7		23400	
7	4		36		1.65		23500	

Solar evaporation of the sugar and distilleries effluent on the 6th day of the experiment

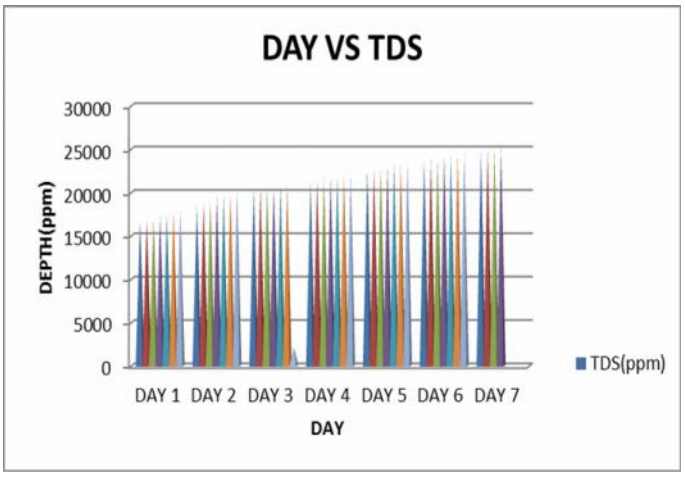
NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		38		1.45		23700	
2	11		40		1.2		23800	
3	12:00 P.M		44		1.1		23900	
4	1		46		0.9		24200	
5	2		37		0.8		24400	
6	3		34		0.7		24500	
7	4		32		0.65		24600	

Solar evaporation of the sugar and distilleries effluent on the 7th day of the experiment

NO	Time (hr)		Temp^0 (c)		Depth (cm)		TDS (ppm)	
	Tank-II	Tank-Ill	Tank-II	Tank-Ill	Tank-II	Tank-III	Tank-II	Tank-Ill
1	10:00 A.M		31.5		0.5		24800	
2	11		32		0.4		24900	
3	12:00 P.M		36		0.2		25100	
4	1		33.6		0.1		25200	
5	2				**Completely Evaporated**		**Salt formed**	



Depth of the Tank at various days (for 20L)



TDS of the Tank at various days (for 20 L)

During Solar Evaporation Process, The Salt Recovered From Treated Effluent In Tank-I And Tank-Ii And Its Weights Are Tabulated Below

NO	Volume of effluent (Litres)	Weight of the total dissolved solids collected from Tank-II (gms)	Weight of the total dissolved solids collected from Tank-II (gms)
1	10	70	98
2	20	150	190

Conclusion

The energy received from the sun comes in the form of light, a short wave radiation but not all of which is visible to human eye. When this radiation strikes a black surface it is absorbed better rather than reflects and thus become more heat and conducts heat energy to evaporation of sugar and distilleries industry effluent or re-radiates heat energy to sugar and distilleries industry effluent of low temperature. Hence there is increase of the temperature of sugar and distilleries industry effluent from 50°c to 80°c and this improves the greater evaporation of sugar and distilleries industry effluent having high TDS. Hence solar energy source have become dependable energy source without any new requirement of highly technical and specialized nature of its wide and comfort utilization. In addition there are no polluting effects create from the use of solar evaporation tank Thermal energy is directly utilized for evaporating the high volume of sugar and distilleries industry effluent which causes pollution in ground water, surface water and all water resources like river and pond. The investigator found that the solar evaporation tank made up of black body kadapa tank function more effectively during summer with high evaporation rate. The number of days took for the evaporation is 7 days for 20 liters in natural black coated kadapa tanks. But it took ten days for the same 20 liters in concrete tanks (observed).

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