Research on operation technology of zero-gradient solar pond

[1]Cao Jinlong [2]Baodong Liu [3]Jialing Zhu [4]Yun Li

[1]Ke Yuan New Energy Tech. Development Co., Ltd. No.177 Wolongdongjie, Weifang City, Shandong Province, 261061 P.R.CHINA Tel:86-536-8781105 86-13706469892 Emeil:jlc@vip.163.com

[2]School of Mathematics, Shandong University 27 Shanda South Road, Jinan, 250100, P.R.China Tel: 86-531-88364652, 86-13793183330 Email: baodong@sdu.edu.cn

[4]Renmin Hospital of ShouGuang No.45 Jiankang Street,Shouguang City Shandong Province, 262700 P.R.CHINA Emeil: sgrmyyly@163.com

Abstract

In the field of freshwater and seawater, through research with particular emphasis on the cause of formation of solar pond, rate of salt-diffusion, thermal stability, operation mechanism of solar pond, negative effect of solar pond, etc., the operation theory of zero-gradient solar pond was put forward, and under the direction of the theory, by taking use of the combination of the method of upwards-spray, infiltration and convection, we completed the research on operation technology of zero-gradient solar pond and achieved many inspiring research outcomes.

Keywords: solar pond ; zero-gradient ; operation technology

0.Technology background

During the tenth Five-year plan, when made research on key technology of integrated heat system for solar pond in winter, we discovered that the DO of lower convective zone promptly reduced to zero, once the integrated heating system with solar pond had been in operation for a period of time, see chart 0(1-2), and produced harmful gases such as H_2S andso on, which had seriously disturbed the eco-environment for object overwintering; In summer and Autumn, gradient always took form in coastal aquaculture pond because of precipitation, moreover, produced negative effect of the solar pond, which had made the problem of how to destroy the large area formation of gradient layer in solar pond be one of the key technologies urgent to be solved in the field of solar pond engineering.

Testing parameters of the physica-chemical factors of the solar pond

Table 0—1 *17:00 Jan.6, 2002*

factors / cm	T ℃	S ppt	DO mg/l	PH	NH^{+}_{3}—N mg/l	NH^{+}_{4}—N mg/l	ΣN mg/l	PO^{+}_{4}—P mg/l	*COD mg/l*
surface	—3.8	5							
20	4.1	7							
40	7.0	10.0	15.96	8.62	1.56	1.67	3.56		*10.7*
60	7.0	15							
80	7.1	20							

100	7.2	22							
120	7.5	22.5							
140	8.0	23	3.98	7.66	2.28	1.84	4.67		*10.0*
160	8.5	23.5							
180	8.6	23.8							
200	9.0	24	3.36	7.68	2.56	1.96	5.12		*9.3*
220	9.0	24							
240	9.0	24							
260	9.0	24							
280	9.5	24							
300	10.0	24	1.71	7.59	2.57	2.28	5.33	0.145	*9.3*
320	*10.0*	*24*							

Testing parameters of the physico-chemical factors of the solar pond

Table0－2 *8:00 Feb.13, 2002*

factors / cm	T ℃	S ppt	DO mg/l	PH	NO_3^-—N mg/l	NH_4^+—N mg/l	ΣN mg/l	PO_4^+—P mg/l	COD mg/l
surface	－5	5.0							
20	1	5.05							
40	1.8	6.1	16.1	9.44	1.60			0.215	9.2
60	2.5	12.17							
80	5.2	18.57							
100	7.0	19.14	5.51	7.69	2.38			0.220	14.2
120	7.5	19.24							
140	8.0	19.24							
160	8.5	21.2	0.52						
180	9.0	22.4							
200	9.8	22.34	0	7.50	3.12			0.245	14.6
220	9.8	23.28							
240	9.8	23.28							
260	9.8	23.28							
280	9.8	23.28							
300	9.8	23.28	0	7.32	3.56			0.245	15.0

1.0 Establish technology solution

Under the background, the discussion team first made a summary for the past twenty years' application of several technologies in the field of seawater cultivation, including overwintering technology of passive solar energy for prawn, overwintering technology of all-weather solar pond for fish, engineering technology of coastal solar pond and solar pond engineering, and on the experience and lesson learnt from research on the integrated heating system with solar pond, studied and analyzed the operation cases of solar pond engineering in other countries, under the direction of thermal engineering theory of solar pond, for the purpose of meeting the urgent need of production, made up the technology solution to research on operation technology of zero-gradient solar pond, see chart 1-1.

2.0 Research methods

2.1 *research on the cause of formation of non-saturation solar pon*d

In lab on Nov 11, 2006, we made 13 experimental ponds in operation, each pond with depth of 80cm and acreage of 0.4 ㎡, and salinity of 1‰、2‰、3‰、4‰、5‰、10‰、15‰、20‰、25‰、30‰、35‰、40‰、50‰ respectively, one month later after the ponds had been in static operation, the salinity of the surface and bottom layer of all ponds had nothing changed, and the testing results of the following one and two months revealed that the salinity of the surface and bottom layer of all ponds were the same; during the period, the temperature of water in all ponds kept between 0 and (to)10℃. The experimental results indicated that salt water pond in static state had stable dynamics and did not take form gradient layer.

Case:

In the Spring of 1987, by taking use of greenhouse solar pond, a leader of the discussion group carried out an experiment on early intensive cultivation of shrimps in Laohekou Shrimp Cultivation Pond in Shouguang, and discovered by chance that the salinity of surface layer of the pond was up to 45‰, but that of the bottom layer was only 35‰. Couple of years later (in 1992-1994), in coastal areas of our country, there was a severely shrimp disease spreading from south to north, for which the cultivation industry for Penaeus orientalis kishinouye in our whole country had suffered fatal strike, the main reason for which was the negative effect of solar pond.

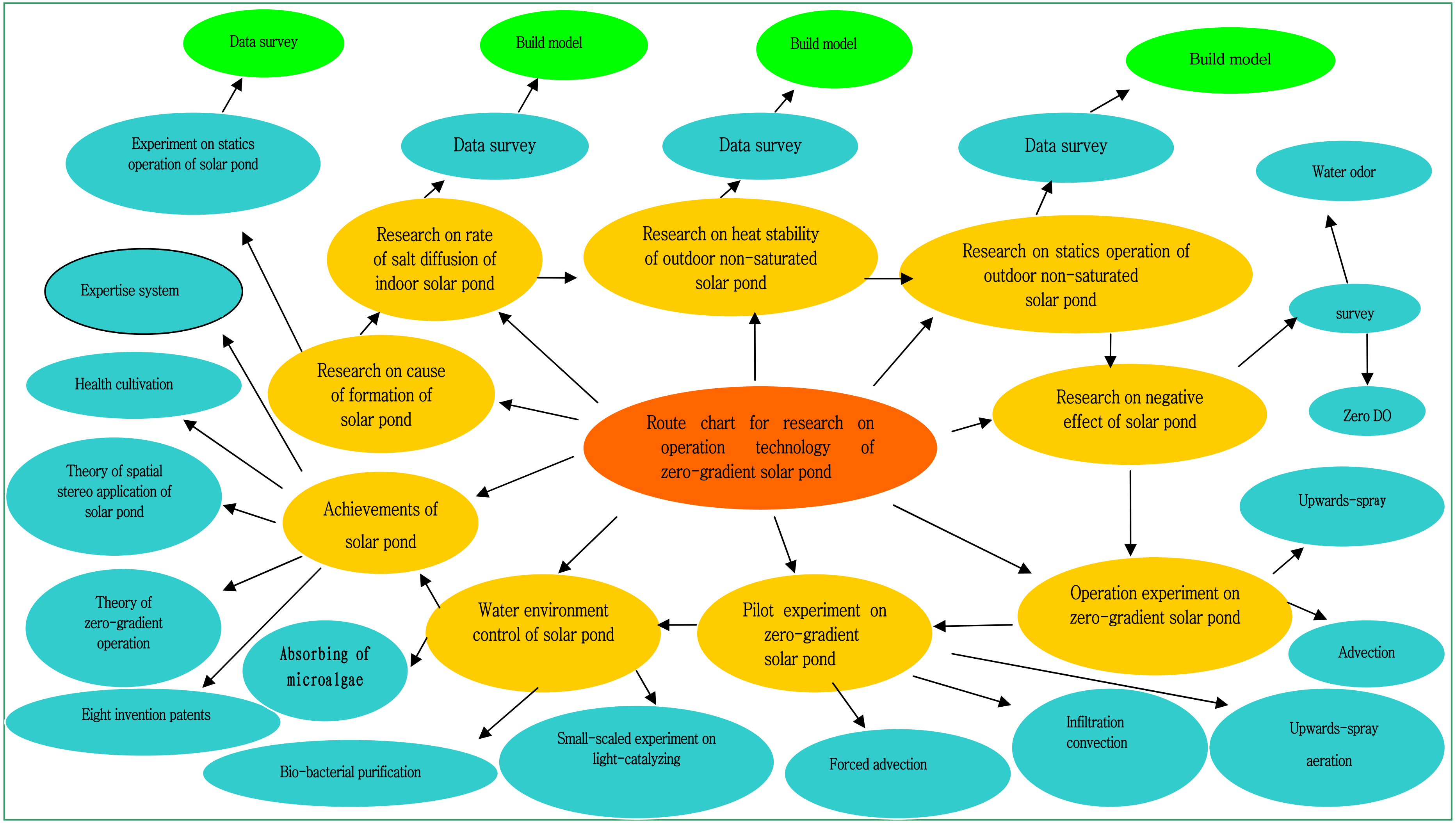
Case analysis:

The experimental result revealed that salt water pond didn't take form gradient under the circumstances of non-precipitation. The formation of gradient in above-mentioned pond was caused by the enhancement of salt accumulation in the bottom soil of the pond. When fresh seawater flowed into pond, in virtue of dissolving of the salt in the soil, the gradient took form in the pond.

2.2 Experiment on salt diffusion of indoor solar pond

Set up 9 groups of indoor solar pond, each with depth of 80cm and acreage of 0.4 ㎡, in order to make things convenient for observing the mixing of the fresh layer water, the fresh water was dyed black.

In the 1st lab, there were 3 groups, each had eleven ponds with salinity of 1‰、5‰、10‰、15‰、20‰、25‰、30‰、35‰、40‰、50‰ respectively, injected fresh water at the volume of 0.5cm、1.0cm、2.0cm into each group respectively.



Data survey
Build model
Build model
Build model
Experiment on statics operation of solar pond
Data survey
Data survey
Data survey
Water odor
Research on rate of salt diffusion of indoor solar pond
Research on heat stability of outdoor non-saturated solar pond
Research on statics operation of outdoor non-saturated solar pond
Expertise system
survey
Research on cause of formation of solar pond
Health cultivation
Route chart for research on operation technology of zero-gradient solar pond
Research on negative effect of solar pond
Zero DO
Theory of spatial stereo application of solar pond
Achievements of solar pond
Upwards-spray
Theory of zero-gradient operation
Water environment control of solar pond
Pilot experiment on zero-gradient solar pond
Operation experiment on zero-gradient solar pond
Absorbing of microalgae
Advection
Eight invention patents
Infiltration convection
Upwards-spray aeration
Small-scaled experiment on light-catalyzing
Forced advection
Bio-bacterial purification

In the 2nd lab, there were three groups, each group had 13 ponds with salinity of 1‰、2‰、3‰、4‰、5‰、10‰、15‰、20‰、25‰、30‰、35‰、40‰、50‰respectively , fresh water at the volume of 3. 0cm、4.0cm、5.0cm was injected into each group respectively;

In the 3rd lab, there were three groups, each group has 13 ponds with salinity of 1‰、2‰、3‰、4‰、5‰、10‰、15‰、20‰、25‰、30‰、35‰、40‰、50‰ respectively, and 6.0cm、7.0cm、8.0cm of fresh water was injected into each group respectively.

Tested the water temperature and salinity fluctuant at a fixed time and location in vertical depth, and probed into the influence of salinity and temperature to the rate of salt diffusion in nature environment.

The experiment discovered, after the injection of 0.5cm fresh water into the 1st group of experimental pond of, freshwater diffusion on the surface of the pond with 1‰ salinity went on slowly in level, but went on rapidly in vertical, and completed 3/5 of the vertical depth in 3 hours. Site tested by a conductivity meter made by American Heating Company, the results showed that there was no gradient on the upper and lower layer of the pond; in the pond with 5‰ salinity, after injection into fresh water, freshwater on the surface diffused rapidly in level, without obvious subsidence, in 5 minutes, the diffused depth of the dyed freshwater layer was 10cm only; the diffusion of this group completed in 19 days.

For the 2nd group of experimental pond, injected into 1.0cm of freshwater, freshwater in the surface layer of pond with 1‰ salinity diffused slowly in level but diffused rapidly in vertical, subsided 32cm in 1 minute, the dyed layer of freshwater sat at the vertical depth of 15cm in 5 minutes; further tested in 12 hours and found there was no gradient in both the upper and lower layer; In the pond with salinity 5‰, after injection into fresh water, freshwater in the surface layer diffused rapidly in level, but without obvious subsidence in vertical, in 5 minutes, the dyed layer sat at the depth of 5cm. The diffusion of this group finished in 37 days;

In the 3rd group, the depth of fresh water layer was 2cm, freshwater in the experimental pond with 1‰ salinity subsided 32cm in 1 minute, upon reached the pond bottom, the black subsidence diffused promptly. The experiment on diffusion was finally finished in 78 days;

For the 4th group of experimental ponds, injected 3cm freshwater into the surface layer, took a test in 48 hours, and the results reflected that the gradient on the surface was 4cm only, made a test in 8 days, the thickness of the gradient layer remained the same, made a test in 15 days, the thickness of the gradient layer reduced by 1cm, and in 21 days, the diffusion was finished; temperature of the experimental pond in the period kept between 4.0 and 6.0 ℃; The diffusion of the group was finally completed in 136 days, including the experimental ponds with a salinity of 10‰，15‰，20‰ respectively; ponds with a high salinity of 25‰ and 35‰ finished diffusion in 129 days; ponds with 35‰和 40‰ salinity finished in 122 days; ponds with 50‰ salinity finished in 107 days. This irregular phenomenon was caused by the sunlight came through windows, by which a temperature field come into being in ponds, and made the ponds nearby windows finish diffusion in advance.

Same phenomenon occurred in the 5th and 6th group of experimental ponds, specific parameters see chart 2-1 for progress of salt diffusion of Indoor salt pond.

Experimental result analysis:
For the 1st experimental group, injected 0.5cm freshwater into the surface layer of the experimental ponds, diffusion of pond with 20‰ salinity(inclusive of 5‰- 50‰ salinity) completed in 19 days; for the 9th experimental group, injected 8cm freshwater into the surface layer of the pond with 20‰ salinity, the diffusion finished in 254 days. The results could be understood that in 80cm vertical depth, it took 19 days and 254 days respectively for water in the bottom layer of pond to overcome salt gradient and reach the surface of the pond.

The data represented that solar pond had excellent heat preservation property and its preservation effect was decided by the freshwater thickness, pond depth and salt concentration gradient.

Inspired by the experimental result, we put forward theory of spatial stereo application of solar pond and invented the solar pond window.

In the 8-month operation period, the inspectionion of experimental ponds for temperature and salinity had been up to 27 times, including couple of times occurrence of solar pond turnover phenomenon, namely, the temperature of bottom water was lower than that of surface water in the experimental pond, particularly in the ponds nearby windows, the phenomenon of surface water temperature higher than that of bottom water was prominently outstanding. See chart 2-5-4-14/2-14/8 and 3-9-8-6/3-8/11 for progress of salt diffusion of indoor pond (chart 2-2, 3).

The occurrence of the phenomenon was caused by the mistake in design of light preventing, for which sunlight came into room through windows in daytime and the indoor air temperature promptly increased, then the surface water absorbed heat firstly and led to the increasing of temperature of the surface water, but the bottom water still kept at the initial temperature due to prevention of heat cycling and conducing from the existing gradient in the upper layer.

However, under the inspiration of turnover phenomenon of solar bond, we invented a cooling method based on temperature control of solar pond.

2.3 ***Research on heat stability of outdoor solar pon****d*
Under outdoor environment conditions, operated12groups of simulation experimental ponds, each pond was 80cm in depth and covered an area of 0.4m^2, and each group had 17 ponds with salinity of 1‰, 2‰, 3‰, 4‰, 5‰, 6‰, 7‰, 8‰, 9‰, 10‰, 15‰, 20‰, 25‰, 30‰, 35‰, 40‰, 50‰ respectively, injected into freshwater at volume of

0.5cm, 1.0cm, 2.0 cm, 3.0cm, 4.0cm, 5.0cm, 6.0cm, 7.0cm, 8.0cm, 9 .0cm, 1 0 .0cm, 15 .0cm respectively, tested salt diffusion in different vertical depth of all ponds in 24-hour all-weather.

The experimental results showed: for the 12 groups of 204 experimental ponds under outdoor environment conditions, the time of completion of salt diffusion was progressively increased with salinity and thickness of freshwater layer; see 2-4 chart for progress of salt diffusion of outdoor solar pond for specific parameters.

Experimental data analysis:

Case 1. For the 1st group of experimental ponds, injected into 0.5cm freshwater, and controlled the water temperature between 22.0-29.0℃, intensity of solar radiation in fine day was 22.37MJ, the instantaneous maximum intensity was up to $837W/m^2$, the completion of freshwater diffusion of pond with 1‰ salinity took 0.9 hour, pond with 2‰ salinity took 4.2 hours, pond with 5‰ salinity took 11.1 hours. The data showed when the salinity of water in coastal area was higher than that of the aquaculture pond with 2‰ salinity, any precipitation more than 5mm had different degrees of risk for cultivated object.

Case 2. In the pond with 1‰ salinity, injected 1cm freshwater into the surface layer, and controlled the water temperature at 21℃ , intensify of solar radiation was 22.37MJ , the freshwater diffusion was completed in 1.1 hours; injected into 2cm freshwater, the diffusion was completed in 1.3 hours, injected into 3cm freshwater, the diffusion was completed in 2.2 hours. The data showed that in the pond with 1‰ salinity, when precipitation was less than 30mm, the gradient layer in the pond existed for a short time, which had no risk to cultivated object. When precipitation was more than 30 mm, the solar pond phenomenon took form in the aquaculture pond for a long time, which caused prompt hypoxia and warm-up of bottom water and production harmful gas, and posed great risk to cultivated object.

Case 3. In the experimental pond with 30‰ salinity, injected into 9cm freshwater and controlled the temperature between 16-29℃ , the intensity of solar radiation in fine day was 22.37MJ, as a result, the diffusion completed in 276 hours(11.5 days); injected into 10cm-thick freshwater, the diffusion completed in 380 hours(15.8 days); injected into 15cm-thick freshwater, the diffusion completed in 618 hours(25.7 days). The data showed the thickness of freshwater layer had direct influence to the operation periods of solar pond, when the water temperature of convection zone of sea solar pond was lower than 29℃ , heating stability was high.

Based on the experimental result, we invented the method of high efficiency utilization of heat for non-saturation solar pond.

2.4 Research on heat stability of outdoor solar pond

In the experimental base for the subject, there were 9 non-saturation solar ponds under operation, covering an area of $70000m^2$ in total; freshwater injection to all ponds was finished

Record for progress of salt diffusion of indoor pond

Chart2-1

Freshwater layer(cm)	ppt / parameter	1	2	3	4	5	10	15	20	25	30	35	40	50
0.5	Days	1/8				19	19	19	19	19	19	19	19	19
	Temp.low/high(℃)	8.4				3.6/8.4	3.6/8.4	3.5/8.4	3.5/8.6	3.5/8.5	3.7/8.7	3.7/8.9	3.6/9.0	3.7/8.6
1.0	Days	1/2				18	24	24	25	31	31	37	37	37
	Temp.low/high(℃)					3.9/7.2	3.1/7.3	3.1/7.5	3.2/7.7	3.1/8.0	3.3/8.0	1.5/8.0	1.5/7.5	1.7/7.8
2.0	Days	6				52	52	78	78	78	78	78	78	78
	Temp.low/high(℃)	5.8/6.6				-0.4/6.9	-0.6/7.1	-0.7/7.1	-0.8/7.3	-0.8/7.1	-0.8/6.7	-0.7/6.9	-0.8/6.8	-0.8/7.0
3.0	Days.	33	92	107	107	122	136	136	136	129	129	122	122	107
	Temp.low/high(℃)	1.9/5.9	1.5/9.8	1.6/2.3	1.8/12.5	1.8/15.4	1.9/21.2	2.1/21.4	2.0/21.4	2.1/15.4	2.2/15.5	2.2/15.6	2.2/15.8	1.8/13.2
4.0	Days	45	116	131	138	138	138	138	138	138	138	138	131	109
	Temp.low/high(℃)	1.4/6.5	1.5/12.5	1.4/15.3	1.6/21.3	1.6/21.2	1.8/21.2	1.6/21.1	1.8/21.2	1.9/21.3	1.8/21.3	1.8/21.5	1.7/15.6	1.6/15.0
5.0	Days	72	131	138	leaking	138	166	166	166	166	166	166	138	124
	Tem.low/high(℃)	1.3/5.6	1.4/15.2	1.5/21.2	1.5/5.7	1.5/21.1	1.7/21.0	1.8/21.0	1.8/21.0	1.8/21.1	1.8/21.1	2.0/21.2	1.8/21.6	1.9/15.6
6.0	Days	106	135	150	171	180	223	223	223	223	223	171	171	150
	Temp.low/high(℃)	0.9/14.5	0.9/21.5	1.2/21.7	1.3/21.6	1.3/21.6	1.5/26.7	1.3/26.6	1.6/26.5	1.6/25.3	1.4/26.5	1.7/21.8	1.5/22.0	1.4/21.8
7.0	Days	91	151	171	171	200	222	222	222	242	222	200	171	151
	Temp.low/high(℃)	1.9/9.1	1.1/21.3	1.1/21.1	1.1/21.3	1.2/25.2	1.3/26.6	1.3/26.5	1.3/26.8	1.5/26.8	1.6/27.0	1.7/25.9	1.7/22.0	1.6/22.8
8.0	Days	121	172	172	201	223	248	254	254	248	254	223	201	172
	Temp.low/high(℃)	0.9/15.2	1.0/21.3	1.0/21.1	1.1/25.2	1.2/26.5	1.3/26.5	1.2/26.3	1.4/26.5	1.6/26.8	1.7/26.9	1.9/26.8	1.9/25.7	1.7/22.1

Record for salt diffusion of indoor pond

2-5-4-14/2-14/8　Chart 2-2

ppt	1.0		2.0		2.9		4.0		5.0		10.1		15.0		20.3		25.1		30.3		35.3		40.4		50.4	
ppt/t h	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃
1			1.7	2.5	2.4	2.5	3.2	2.6	3.8	2.8	7.6	2.9	11.1	3.0	15.2	3.1	18.6	3.3	23.4	3.5	28.1	4.5	32.9	6.1	44.1	7.0
2			1.7	2.5	2.4	2.5	3.2	2.6	3.8	2.8	7.7	2.8	11.1	3.0	15.3	3.1	18.7	3.3	23.4	3.5	28.2	4.3	32.9	6.0	44.1	6.7
3			1.8	2.5	2.4	2.5	3.2	2.6	3.9	2.8	7.8	2.8	11.2	3.0	15.4	3.1	18.9	3.3	23.6	3.5	28.3	4.2	32.9	5.9	44.3	6.4
4			1.8	2.5	2.5	2.5	3.2	2.6	3.9	2.8	7.9	2.8	11.4	3.0	15.6	3.1	19.1	3.3	23.8	3.5	28.4	4.1	32.9	5.8	44.3	6.1
5			1.8	2.5	2.5	2.5	3.2	2.6	4.0	2.8	8.0	2.8	11.7	3.0	16.0	3.1	19.5	3.3	24.1	3.5	28.9	4.0	32.9	5.4	44.6	5.8
6			1.8	2.5	2.5	2.5	3.3	2.6	4.1	2.8	8.1	2.8	12.0	3.0	16.4	3.1	19.8	3.3	24.5	3.5	28.9	3.9	32.9	5.3	44.6	5.0
7			1.8	2.5	2.6	2.5	3.5	2.6	4.2	2.8	8.3	2.8	12.3	3.0	16.6	3.1	20.1	3.3	25.0	3.5	29.4	3.9	32.9	4.3	44.6	4.7
8			1.8	2.5	2.6	2.5	3.5	2.6	4.4	2.8	8.4	2.8	12.4	3.0	17.0	3.1	20.5	3.3	25.3	3.5	29.7	3.9	33.8	4.2	44.8	4.4
9			1.8	2.5	2.6	2.7	3.5	2.7	4.6	2.9	8.6	2.8	13.1	3.0	17.3	3.1	21.0	3.3	25.9	3.5	30.4	3.9	34.5	4.1	45.2	4.3
10			1.9	2.5	2.7	2.7	3.8	2.7	4.6	2.9	8.7	2.9	13.2	3.0	17.7	3.1	21.6	3.3	26.4	3.5	31.0	3.9	35.7	4.1	46.0	3.8
20			2.0	2.6	2.9	2.8	3.9	2.8	4.8	2.9	9.9	3.0	14.9	3.0	20.3	3.1	24.9	3.3	29.6	3.6	34.8	3.9	36.4	4.0	50.4	3.7
30			2.0	2.6	2.9	2.8	4.0	2.8	5.0	2.9	9.9	3.0	15.0	3.0	20.3	3.1	25.1	3.4	30.3	3.6	35.3	3.9	40.4	4.0	50.4	3.7
40			2.0	2.6	2.9	2.9	4.0	2.9	5.0	2.9	10.1	3.0	15.0	3.0	20.3	3.1	25.1	3.4	30.3	3.6	35.3	3.9	40.4	4.0	50.4	3.7
50			2.0	2.7	2.9	2.9	4.0	2.9	5.0	2.9	10.1	3.0	15.0	3.0	20.3	3.1	25.1	3.4	30.3	3.6	35.3	3.9	40.4	4.0	50.4	3.7
60			2.0	2.7	2.9	2.9	4.0	2.9	5.0	2.9	10.1	3.0	15.0	3.0	20.3	3.1	25.1	3.4	30.3	3.6	35.3	3.9	40.4	4.0	50.4	3.7
70			2.0	2.7	2.9	2.9	4.0	2.9	5.0	2.9	10.1	3.0	15.0	3.1	20.3	3.1	25.1	3.4	30.3	3.6	35.3	3.9	40.4	4.0	50.4	3.7
80			2.0	2.6	2.9	2.9	4.0	2.9	5.0	2.9	10.1	3.0	15.0	3.1	20.3	3.1	25.1	3.4	30.3	3.6	35.3	3.9	40.4	4.0	50.4	3.7

Record for salt diffusion of indoor pond

3-9-8-6/3-8/11 Chart 2-3

ppt	1.1		2.2		3.1		4.0		5.2		10.3		15.2		20.2		25.9		31.0		35.9		41.1		50.5	
ppt/t h	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃
1	0.9	6.5	1.5	6.4	2.0	6.5	2.4	6.4	3.0	6.9	5.7	6.6	8.1	6.6	10.6	6.7	13.7	6.8	17.2	7.0	20.3	7.6	25.0	7.8	32.2	9.7
2	0.9	6.5	1.5	6.4	2.0	6.5	2.4	6.4	3.0	6.8	5.7	6.6	8.1	6.6	10.7	6.7	13.8	6.8	17.3	7.0	20.3	7.6	25.0	7.8	32.2	9.5
3	0.9	6.5	1.5	6.4	2.0	6.5	2.4	6.4	3.0	6.8	5.9	6.6	8.1	6.6	11.1	6.7	14.2	6.8	17.4	7.0	20.5	7.5	25.1	7.8	32.2	9.2
4	1.0	6.5	1.5	6.4	2.0	6.5	2.5	6.4	3.1	6.8	6.2	6.6	8.7	6.6	11.4	6.7	14.4	6.8	17.9	7.0	21.0	7.5	25.3	7.8	32.5	9.0
5	1.0	6.5	1.5	6.4	2.1	6.5	2.6	6.4	3.3	6.7	6.3	6.6	8.9	6.6	11.9	6.7	15.0	6.8	18.4	7.0	21.8	7.4	25.7	7.8	32.9	8.8
6	1.0	6.5	1.5	6.4	2.1	6.5	2.6	6.4	3.3	6.7	6.6	6.6	9.2	6.6	12.3	6.7	15.7	6.8	19.0	7.0	22.2	7.4	26.5	7.8	33.5	8.6
7	1.0	6.5	1.5	6.4	2.1	6.5	2.7	6.4	3.4	6.6	7.0	6.6	9.5	6.6	12.6	6.7	16.2	6.8	19.8	7.0	23.0	7.4	27.2	7.8	34.0	8.5
8	1.0	6.5	1.6	6.4	2.2	6.5	2.8	6.4	3.7	6.6	7.2	6.6	9.7	6.6	13.4	6.7	16.9	6.8	19.9	7.0	24.0	7.4	28.2	7.8	35.5	8.4
9	1.0	6.5	1.8	6.4	2.2	6.5	2.8	6.4	3.7	6.6	7.2	6.6	10.4	6.6	14.0	6.7	17.9	6.8	25.2	7.0	25.1	7.4	29.3	7.8	37.0	8.3
10	1.0	6.5	1.8	6.4	2.3	6.5	2.9	6.4	3.7	6.5	7.9	6.6	10.8	6.6	14.1	6.7	18.5	6.8	23.1	7.0	25.6	7.3	29.9	7.8	38.0	8.2
20	1.1	6.5	2.2	6.4	3.0	6.5	3.9	6.4	4.9	6.5	9.7	6.6	14.2	6.6	18.7	6.7	24.1	6.8	28.9	7.0	33.9	7.3	39.3	7.8	48.0	8.2
30	1.1	6.5	2.2	6.4	3.1	6.5	4.0	6.4	5.2	6.5	10.3	6.6	15.2	6.6	20.2	6.7	25.9	6.8	31.0	7.0	35.9	7.3	40.6	7.8	50.5	8.1
40	1.1	6.5	2.2	6.4	3.1	6.5	4.0	6.4	5.2	6.5	10.3	6.6	15.2	6.6	20.2	6.7	25.9	6.8	31.0	7.0	35.9	7.3	41.1	7.8	50.5	8.0
50	1.1	6.5	2.2	6.4	3.1	6.5	4.0	6.4	5.2	6.5	10.3	6.6	15.2	6.6	20.2	6.7	25.9	6.8	31.0	7.0	35.9	7.3	41.1	7.8	50.5	8.0
60	1.1	6.5	2.2	6.4	3.1	6.5	4.0	6.4	5.2	6.5	10.3	6.6	15.2	6.6	20.2	6.7	25.9	6.8	31.0	7.0	35.9	7.3	41.1	7.8	50.5	8.0
70	1.1	6.5	2.2	6.4	3.1	6.5	4.0	6.4	5.2	6.5	10.3	6.6	15.2	6.6	20.2	6.7	25.9	6.8	31.0	7.0	35.9	7.3	41.1	7.8	50.5	8.0
80	1.1	6.5	2.2	6.4	3.1	6.5	4.0	6.4	5.2	6.5	10.3	6.6	15.2	6.6	20.2	6.7	25.9	6.8	31.0	7.0	35.9	7.3	41.1	7.8	50.5	8.0

Chart for progress of salt diffusion of outdoor solar pond

Longitude/Latitude: 118.7° 37.0°

Depth of solar pond: 80cm Chart 2-4

Freshwater layer （cm）	ppt / parameter	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	50
0.5	time（h）	0.9	4.2	5.0	6.4	6.4	7.1	7.7	7.7	8.2	8.2	8.8	9.4	10.3	10.3	11.1	11.1	11.1
	Temp.L/hi（℃）	22/23	22/26	22/28	22/28	22/29	22/29	22/29	22/29	22/29	22/29	22/29	23/28	22/27	22/27	23/26	23/26	23/26
	Turbidity	4.9	7.5	8.0	2.4	19.4	7.4	3.8	7.6	6.0	2.2	5.1	5.1	7.3	4.7	6.0	9.8	8.5
	Radiation intensity（MJ）	0.58	5.65	8.18	10.82	10.82	13.16	13.16	13.16	15.7	15.7	17.9	17.9	19.48	19.48	20.56	20.56	20.56
1	time（h）	1.1	4.7	7.7	8.4	9.0	9.0	10.0	11.7	12.8	13.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0
	Temp. low/high（℃）	23	23/29	23/29	23/28	23/27	23/28	23/27	23/26	23/25	23/24	23	19/23	19/23	19/23	19/23	19/23	19/23
	Turbidity	5.7	11.0	10.0	8.7	3.9	15.4	8.7	9.1	14.1	15.5	15.7	3.6	7.8	7.8	0.3	3.6	9.5
	Radiation intensity（MJ）	1.14	16.18	17.76	17.76	19.34	19.34	20.02	20.19	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2
2	time（h）	1.3	5.0	8.0	9.4	11.0	12.0	13.0	14.7	15.0	16.0	17.0	18.0	19.0	20.1	21.0	23.0	23.0
	Temp. low/high（℃）	21.3	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26	22/26
	Turbidity	1.1	2.2	1.2	1.3	1.5	2.2	14.5	2.2	5.0	3.5	3.6	3.6	7.8	7.8	0.3	3.6	9.5
	Radiation intensity（MJ）	1.14	6.54	13.93	19.53	19.53	19.53	19.53	19.53	19.53	19.53	19.53	19.53	19.53	19.53	19.53	19.53	19.53
3	time（h）	2.2	8.0	9.0	10.0	13.0	18.0	21.0	22.0	23.0	25.0	35.0	61.0	70.0	75.0	78.0	80.0	81.0
	Temp. low/high（℃）	22.0	22/29	22/29	22/29	24/29	24/29	24/29	24/29	24/29	24/29	24/29	24/29	24/29	24/29	24/29	24/29	24/29
	Turbidity	1.1	2.2	1.2	1.3	1.5	2.2	14.5	2.2	5.0	3.5	3.6	3.6	7.8	7.8	0.3	3.6	9.5
	Radiation intensity（MJ）	1.72	15.67	15.67	15.67	17.01	17.01	17.01	17.01	17.01	17.01	30.11	46.15	46.15	46.15	46.15	46.15	46.15
4	time（h）	4.0	9.0	10.0	12.0	15.0	22.0	25.0	27.0	29.0	31.0	43.0	83.0	91.0	95.0	97.0	98.0	100
	Temp.low/high（℃）	27.0	30.0	30.0	30.0	24/30	24/30	24/30	24/30	24/30	24/30	24/30	24/30	24/30	24/30	24/30	24/30	24/30
	Turbidity	1.1	2.2	1.2	1.3	1.5	2.2	14.5	2.2	5.0	3.5	3.6	3.6	7.8	7.8	0.3	3.6	9.5
	Radiation intensity（MJ）	10.24	12.97	12.97	12.97	16.25	16.25	16.25	16.25	16.25	16.25	33.26	62.4	62.4	62.4	62.4	62.4	62.4
5	time（h）	5.4	20.0	23.0	31.0	40.0	61.0	70.0	76.0	86.0	98.0	116	120	126	130	135	138	140
	Temp. low/high（℃）	25.0	17.0	17.0	17.0	17/28	17/28	17/28	17/28	17/28	17/28	17/28	17/28	17/28	17/28	17/28	17/28	17/28
	Turbidity	2.5	2.8	1.3	0.7	0.4	0.8	9.0	5.1	8.6	4.7	2.1	1.1	2.3	1.5	2.6	3.4	15.4
	Radiation intensity（MJ）	11.44	18.85	18.85	18.85	37.86	56.85	56.85	56.85	77.06	77.06	77.06	93.31	93.31	93.31	93.31	93.31	93.31

6	time（h）	6.1	26.0	44.0	54.0	63.0	78.0	80.0	87.0	93.0	100	117	127	137	138	140	150	161
	Temp. low/high（℃）	28.0	17.0	17/21	17/21	17/26	17/26	17/26	17/26	17/26	17/26	17/26	17/26	17/26	17/31	17/31	17/31	17/31
	Turbidity	1.5	1.2	1.7	0.2	2.3	3.3	1.1	5.7	1.5	0.5	4.3	18.7	2.2	2.6	13.7	2.4	10.8
	Radiation intensity（MJ）	16.18	18.85	37.86	37.86	56.85	77.06	77.06	77.06	77.06	77.06	77.06	77.06	77.06	110.32	110.32	110.32	110.32
7	time（h）	6.6	28.0	48.0	60.0	70.0	80.0	85.0	90.0	98.0	107	131	143	150	170	176	201	206
	Temp.low/high（℃）	28.0	17.0	17.0	17/27	17/27	17/27	17/27	17/27	17/27	17/27	17/27	17/30	17/30	17/30	17/30	17/30	17/30
	Turbidity	1.5	1.2	1.7	0.2	2.3	3.3	1.1	5.7	1.5	0.5	4.3	18.7	2.2	2.6	13.7	2.4	10.8
	Radiation intensity（MJ）	16.18	18.85	18.85	5685	56.85	77.06	77.06	77.06	77.06	77.06	93.31	93.31	110.32	110.32	110.32	110.32	110.32
8	time（h）	6.8	29.0	52.0	71.0	75.0	85.0	90.0	100	102	112	136	147	157	190	200	202	207
	Temp. low/high（℃）	28.8	17.0	17/21	17/26	17/26	17/26	17/26	17/26	17/26	17/26	17/26	17/26	17/29	17/29	17/29	17/29	17/29
	Turbidity	1.5	1.2	1.7	0.2	2.3	3.3	1.1	5.7	1.5	0.5	4.3	18.7	2.2	2.6	13.7	2.4	10.8
	Radiation intensity（MJ）	16.18	18.85	37.86	56.85	76.38	76.38	76.38	76.38	76.38	76.38	77.06	93.31	93.31	139.45	139.45	139.45	139.45
9	time（h）	7.0	51.0	61.0	95.0	100	102	115	126	160	182	190	224	254	276	304	310	324
	Temp. low/high（℃）	26.0	16.0	16.0	16/26	16/26	16/26	16/26	16/26	16/26	16/26	16/29	16/29	16/29	16/29	16/29	16/29	16/29
	Turbidity	15.0	6.2	4.3	12.4	2.3	5.9	14.4	4.0	2.1	2.3	0.9	0.4	5.0	1.8	0.3	5.5	14.4
	Radiation intensity（MJ）	5.71	32.13	32.13	70.13	89.66	89.66	89.66	90.34	90.34	90.34	106.59	152.73	152.73	167.9	198.1	198.1	198.1
10	time（h）	7.5	63.0	73.0	99.0	109	109	123	133	167	188	201	263	311	380	390	400	405
	Temp. low/high（℃）	26/29	17/20	17/20	17/23	17/23	17/23	17/24	17/24	17/29	17/29	17/29	17/29	17/29	17/29	17/29	17/29	17/29
	Turbidity	3.4	0.3	2.2	1.8	0.7	6.1	3.2	12.9	5.4	5.4	5.2	3.5	3.4	1.1	3.9	1.2	4.1
	Radiation intensity（MJ）	5.72	54.14	51.14	70.13	70.13	70.13	89.66	89.66	90.34	90.34	90.34	152.73	228.49	297.59	297.59	297.59	297.59
15	time（h）	8.0	72.0	108	110	128	131	133	153	203	391	415	598	608	618	620	640	646
	Temp. low/high（℃）	26/30	17/28	17/28	17/28	17/28	17/28	17/29	17/29	17/29	17/29	17/29	17/29	17/29	17/29	17/29	17/29	17/29
	Turbidity	4.6	6.3	3.0	2.0	10.1	0.8	0.2	0.2	4.0	0.4	2.5	0.6	3.3	0.9	3.0	5.0	3.9
	Radiation intensity（MJ）	1.94	18.85	76.38	76.38	77.06	77.06	93.31	93.31	124.42	256.44	271.46	347.74	347.74	347.74	347.74	347.74	347.74

on Jan 26, 2008 and data test set out on Feb 14,2008. The experiment, including the phase of freshwater injection and diffusion completion, was completely made under natural environment, which fully reflected the formation and change of salt-gradient in non-saturation solar pond (salt aquaculture pond) in the area of Yellow River Delta. Specific operation parameter was shown in chart 2-(5-13).

Record for salt diffusion of outdoor non-saturated solar pond

Chart2-5 Feb 2, 2008 8:00-10:00 the first time examination

No.	1		2		3		4		5		6		7		8		9	
ppt/t cm	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃
layer	1.1	0	1.3	0	1.4	0	1.5	0	6.6	0	1.3	0	0.8	0	0.8	0	0.8	0
10	1.1	3.4	1.3	2.1	1.4	2.2	1.5	1.3	6.6	0.2	1.3	1.2	0.8	1.2	0.8	1.3	0.8	2.1
20	1.1	3.4	1.4	2.5	1.5	2.6	1.6	1.9	7.3	1.2	1.3	2.3	0.8	2.1	0.8	1.9	0.8	2.1
30	1.1	3.4	2.0	3.0	1.5	2.8	1.6	2.5	10.0	2.8	1.3	2.5	0.8	2.5	0.8	2.5	0.8	2.5
40	1.1	3.4	2.4	3.4	1.5	3.1	1.6	2.7	16.6	3.2	1.3	2.7	0.8	2.8	0.8	2.6	0.8	2.8
50	1.1	3.4	2.4	3.4	1.5	3.5	9.0	5.8	20.5	4.5	1.7	3.0	0.8	3.0	0.8	2.8	0.8	3.0
60	1.1	3.5	2.4	3.5	1.5	3.5	12.6	6.4	20.6	5.7	2.0	3.5	0.8	3.3	0.8	3.0	0.8	3.2
70	1.1	3.6	2.5	4.0	1.6	3.8	14.8	7.1	20.7	6.3	2.2	4.5	0.8	3.4	0.8	3.2	0.8	3.2
80	1.1	3.7	2.7	4.2	1.7	4.1	17.0	7.8	20.8	6.7	2.4	5.6	0.8	3.6	0.8	3.3	0.8	3.3
90	1.2	3.8	3.6	5.0	2.1	4.9	17.1	8.3	20.8	7.0	3.0	6.7	1.0	4.6	1.1	3.8	0.8	4.5
100	1.3	3.9	5.9	6.3	3.0	6.0	17.2	8.8	20.8	7.2	3.9	7.2	2.3	5.8	2.4	4.1	2.1	5.0
110	3.5	4.3	8.7	7.0	3.5	6.9	17.5	9.0	20.8	7.5	8.5	7.6	4.0	6.2	4.2	5.0	4.6	5.5
120	4.5	5.8	9.6	7.6	4.0	7.7	17.7	9.4	20.9	7.8	16.7	8.2			5.1	5.7	5.7	5.7
130	10.0	6.8			6.1	8.5			21.0	8.0	17.0	8.6					6.0	6.6
140	17.2	7.4			8.0	9.2			21.2	8.2	17.9	8.8					6.4	7.2

Record for salt diffusion of outdoor non-saturated solar pond

Chart 2-6 on the morning of Feb 21, 2008

No.	1		2		3		4		5		6		7		8		9	
ppt/t cm	S ppt	T (℃)	S ppt	T (℃)	S ppt	T (℃)	S ppt	T (℃)	S ppt	T ℃)	S ppt	T (℃)	S ppt	T ℃)	S ppt	T (℃)	S ppt	t (℃)
layer	0.7	0	1.1	0	0.7	0			2.8	0	0.7	0	0.1	0	0.3	0	0.5	0
10	1.1	2.8	1.6	2.8	1.4	2.8			3.3	2.4	0.8	2.8	0.3	2.8	0.6	2.7	0.5	2.8
20	1.1	5.3	2.2	5.1	1.4	6.1			6.6	5.5	1.3	5.7	0.7	6.4	0.8	6.0	0.8	5.5
30	1.1	5.3	2.2	5.2	1.4	6.2			10.1	7.3	1.3	6.2	0.8	6.4	0.8	6.1	0.8	5.6
40	1.1	5.4	2.3	5.2	1.4	6.3			14.1	8.1	1.3	6.8	0.8	6.5	0.8	6.2	0.8	5.7
50	1.1	5.4	2.3	5.4	1.4	6.4			18.3	8.9	1.5	7.6	0.8	6.7	0.8	6.3	0.8	6.0
60	1.1	5.4	2.3	5.5	1.4	6.9			19.9	9.1	1.9	8.3	0.8	6.9	0.8	6.5	0.8	6.2
70	1.2	5.5	2.3	5.8	1.5	7.4			20.0	9.1	2.0	8.9	0.8	7.3	0.8	6.7	0.8	6.3
80	1.3	5.6	2.9	6.0	1.9	8.1			20.0	9.1	2.3	9.2	0.8	7.5	0.8	7.0	0.8	6.5
90	1.5	5.8	3.9	6.0	2.6	8.5			20.2	9.1	2.6	9.3	1.2	7.7	1.3	7.3	1.2	6.8
100	2.7	6.8			2.9	8.8			20.3	9.1	4.4	9.4	2.5	7.7	2.0	7.7	2.3	6.9

110	3.7	7.0			3.2	9.0			20.8	9.1	8.6	9.5			5.7	7.7	4.4	7.3
120	4.8	8.5			3.8	9.1					13.5	9.5					6.8	7.3
130	9.5	9.0			4.3	9.1												
140	15.0	9.3																

Record for salt diffusion of outdoor non-saturated solar pond

Chart 2-7 Ice melting in pond No.3 Feb 28, 2008 8:00-11:00

No.	1		2		3		4		5		6		7		8		9	
ppt/t	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T
cm	ppt	(℃)	ppt	(℃)	ppt	(℃)	ppt	(℃)	ppt	(℃)	ppt	(℃)	ppt	℃)	ppt	℃)	ppt	(℃)
layer	0.7	0	1.1	0	0.7	0			2.8	0	0.7	0	0.1	0	0.3	0	0.5	0
10	1.1	2.8	1.6	2.8	1.4	2.8			3.3	2.4	0.8	2.8	0.3	2.8	0.6	2.7	0.5	2.8
20	1.1	5.3	2.2	5.1	1.4	6.1			6.6	5.5	1.3	5.7	0.7	6.4	0.8	6.0	0.8	5.5
30	1.1	5.3	2.2	5.2	1.4	6.2			10.1	7.3	1.3	6.2	0.8	6.4	0.8	6.1	0.8	5.6
40	1.1	5.4	2.3	5.2	1.4	6.3			14.1	8.1	1.3	6.8	0.8	6.5	0.8	6.2	0.8	5.7
50	1.1	5.4	2.3	5.4	1.4	6.4			18.3	8.9	1.5	7.6	0.8	6.7	0.8	6.3	0.8	6.0
60	1.1	5.4	2.3	5.5	1.4	6.9			19.9	9.1	1.9	8.3	0.8	6.9	0.8	6.5	0.8	6.2
70	1.2	5.5	2.3	5.8	1.5	7.4			20.0	9.1	2.0	8.9	0.8	7.3	0.8	6.7	0.8	6.3
80	1.3	5.6	2.9	6.0	1.9	8.1			20.0	9.1	2.3	9.2	0.8	7.5	0.8	7.0	0.8	6.5
90	1.5	5.8	3.9	6.0	2.6	8.5			20.2	9.1	2.6	9.3	1.2	7.7	1.3	7.3	1.2	6.8
100	2.7	6.8			2.9	8.8			20.3	9.1	4.4	9.4	2.5	7.7	2.0	7.7	2.3	6.9
110	3.7	7.0			3.2	9.0			20.8	9.1	8.6	9.5			5.7	7.7	4.4	7.3
120	4.8	8.5			3.8	9.1					13.5	9.5					6.8	7.3
130	9.5	9.0			4.3	9.1												
140	15.0	9.3																

Record for salt diffusion of outdoor non-saturated solar pond

Chart2-8 Mar. 6, 2008 8:30 start-up

No.	1		2		3		4		5		6		7		8		9	
ppt/t	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T
(cm)	ppt	℃	ppt	℃	ppt	℃	ppt	℃	ppt	℃	ppt	℃	ppt	℃	ppt	℃	ppt	℃
layer	1.3	7.7	2.7	7.4	1.8	7.5	2.6	7.5	6.1	6.7	1.8	7.5	1.0	7.9	1.1	7.8	1.2	7.6
10	1.3	7.7	2.7	7.4	1.8	7.5	2.6	7.6	6.1	7.2	1.8	7.6	1.0	7.9	1.1	7.8	1.2	7.6
20	1.5	7.7	2.7	7.4	1.8	7.5	2.6	7.8	6.1	7.2	1.8	7.7	1.0	7.9	1.1	7.8	1.2	7.6
30	1.5	7.7	2.7	7.4	1.8	7.5	2.6	8.1	8.8	10.9	1.8	7.7	1.0	7.9	1.1	7.8	1.2	7.6
40	1.5	7.7	2.7	7.4	1.8	7.5	2.6	8.5	14.7	12.9	1.8	7.8	1.0	7.9	1.1	7.8	1.2	7.6
50	1.5	7.7	2.7	7.4	1.8	7.5	2.8	10.1	18.7	14.3	1.8	8.1	1.0	7.8	1.1	7.8	1.3	7.7
60	1.5	7.7	2.7	7.4	1.8	7.5	11.0	12.8	20.2	14.4	1.8	8.4	1.0	7.8	1.1	7.8	1.3	7.8
70	1.5	7.7	2.7	7.4	1.8	7.5	16.8	14.6	20.2	14.4	1.8	8.8	1.0	7.8	1.1	7.8	1.3	7.9
80	1.5	7.7	2.7	7.4	1.8	7.5	17.1	14.6	20.2	14.4	2.5	9.8	1.0	7.7	1.1	7.8	1.3	8.0
90	1.5	7.8	4.2	7.5	1.8	7.5	17.3	14.6	20.2	14.4	6.3	10.5	1.0	7.5	1.2	7.9	1.3	8.3
100	1.5	7.8		`	1.8	7.6	17.6	14.6	20.3	14.4	11.0	10.8			2.1	7.9	1.7	8.9
110	1.5	7.8			1.9	7.7	18.4	14.6	20.4	14.4	13.9	11.2					2.9	9.5
120					3.2	7.7											6.2	9.9

130																	6.7	9.9
140																		

The first time examination after ice melting

Salt-diffusion of pond No.7within a depth range of 0.9m finished in 22 days

Record for salt diffusion of outdoor non-saturated solar pond

Chart 2-9 Mar. 22, 2008 8:00

No.	1		2		4		5		6		7		8		9	
Ppt (cm)	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃
layer	1.5	10.7	3.1	10.3	4.0	10.6	8.2	8.3	2.2	10.4	1.1	10.7	1.2	10.6	1.4	10.5
10	1.5	10.7	3.1	10.3	4.0	10.7	8.2	8.9	2.2	10.4	1.1	10.7	1.2	10.6	1.4	10.5
20	1.5	10.7	3.1	10.3	4.0	10.7	8.2	9.4	2.2	10.4	1.1	10.8	1.2	10.6	1.4	10.5
30	1.5	10.7	3.1	10.3	4.0	10.8	10.3	11.5	2.2	10.4	1.1	10.8	1.2	10.6	1.4	10.5
40	1.5	10.7	3.1	10.3	4.0	10.9	15.9	12.7	2.2	10.5	1.1	10.8	1.2	10.6	1.4	10.5
50	1.5	10.7	3.1	10.3	4.0	11.4	19.9	18.8	2.2	10.6	1.1	10.8	1.2	10.5	1.4	10.5
60	1.5	10.7	3.1	10.3	4.0	12.1	20.0	18.8	2.2	10.6	1.1	10.8	1.2	10.5	1.4	10.5
70	1.5	10.8	3.1	10.3	14.8	14.1	20.0	18.8	2.2	10.7	1.1	10.8	1.2	10.4	1.4	10.5
80	1.5	10.8	3.1	10.2	16.4	17.0	20.0	18.8	2.4	10.9	1.1	10.8	1.2	10.4	1.4	10.5
90	1.5	10.8			16.4	17.0	20.0	18.8	3.7	11.1	1.1	10.9	1.2	10.3	1.4	10.6
100	1.5	11.0			16.5	17.0	20.0	18.8	7.0	13.0			1.2	10.1	1.4	10.8
110	1.5	11.2			16.6	17.0	20.0	18.8	13.4	13.3					2.4	11.7
120															4.4	12.0
130																
140																

Salt-diffusion of pond No.1 within a depth range of 1.1m finished in 30 days

Salt-diffusion of pond No.2 within a depth range of 0.8m finished in 30 days

Record for salt diffusion of outdoor non-saturated solar pond

Chart 2-10 Mar. 30, 2008 8:30

No.	1		2		3		4		5		6		7		8		9	
ppt/t (cm)	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃
layer					2.7	9.8	6.2	10.3	12.2	10.6	2.9	10.1					1.5	10.4
10					2.7	9.8	6.2	10.3	12.2	10.6	2.9	10.1					1.5	10.4
20					2.7	9.8	6.2	10.4	12.2	10.6	2.9	10.1					1.5	10.4
30					2.7	9.8	6.2	10.4	12.2	10.6	2.9	10.1					1.5	10.4
40					2.7	9.8	6.2	10.4	12.2	10.6	2.9	10.1					1.5	10.4
50					2.7	9.8	6.2	10.4	18.0	13.5	2.9	10.2					1.5	10.4
60					2.7	9.8	6.2	10.4	19.2	15.4	2.9	10.2					1.5	10.4
70					2.8	9.9	6.5	11.5	19.2	15.4	2.9	10.3					1.5	10.4
80					2.8	9.9	11.1	13.2	19.3	15.4	2.9	10.5					1.5	10.4
90					2.8	9.9	15.8	14.0	19.3	15.4	3.1	11.0					1.5	10.4

100					2.8	9.9	15.8	14.0	19.3	15.4	4.5	11.8					1.5	10.4
110					2.8	9.9	15.8	14.0	19.5	15.4	10.4	12.6					1.5	10.4
120							15.8	14.0									1.5	10.4
130																		
140																		

Salt-diffusion of pond No.9 within a depth range of 1.2m finished in 38 days

Record for salt diffusion of outdoor non-saturated solar pond

Chart 2-11 Mar. 30, 2008 8:30

No.	1		2		3		4		5		6		7		8		9	
ppt/t cm	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃
layer					3.1	9.1	6.9	8.9	14..5	9.6	3.4	9.4						
10					3.1	9.1	6.9	8.9	14.5	9.6	3.4	9.4						
20					3.1	9.1	6.9	8.9	14.5	9.6	3.4	9.4						
30					3.1	9.1	6.9	8.9	14.5	9.6	3.4	9.4						
40					3.1	9.0	6.9	8.9	14.5	9.6	3.4	9.4						
50					3.1	9.0	6.9	9.0	14.5	9.6	3.4	9.4						
60					3.1	9.0	6.9	9.0	14.5	9.7	3.4	9.4						
70					3.1	9.0	6.9	9.1	18.8	13.2	3.4	9.4						
80					3.1	9.0	6.9	9.3	18.8	13.2	3.4	9.4						
90					3.1	9.0	11.7	13.6	18.8	13.2	3.4	9.5						
100					3.1	8.9	11.8	13.6	18.8	13.2	3.4	9.5						
110					3.1	8.9	11.9	13.6	18.8	13.2	10.5	10.9						
120																		
130																		
140																		

Salt-diffusion of pond No.3 within a depth range of 1.1m finished in 46 days

Record for salt diffusion of outdoor non-saturated solar pond

Chart 2-12 Apr. 9, 2008 8:00

No.	1		2		3		4		5		6		7		8		9	
ppt/t (cm)	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃
layer							7.9	14..8	16.7	15.3	4.4	15.2						
10							7.9	14..8	16.7	15.3	4.4	15.2						
20							7.9	14.8	16.7	15.3	4.4	15.2						
30							7.9	14.8	16.7	15.3	4.4	15.2						
40							7.9	14.8	16.7	15.3	4.4	15.2						
50							7.9	14.8	16.7	15.3	4.4	15.2						
60							7.9	14.9	16.7	15.3	4.4	15.2						
70							7.9	14.9	16.7	15.3	4.4	15.2						
80							7.9	14.9	16.7	15.3	4.4	15.2						

90							7.9	14.9	16.7	15.3	4.4	15.2						
100							7.9	15.1	16.7	15.3	4.4	15.2						
110							10.4	15.6										
120																		
130																		
140																		

Salt-diffusion of pond No.5 and No. 6 within a depth range of 1.0 m finished in 55 days

Record for salt diffusion of outdoor non-saturated solar pond

Chart 2-13 Apr. 17, 2008 10:30

No.	1		2		3		4		5		6		7		8		9	
ppt/t cm	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃	S ppt	T ℃
layer							8.2	**19.2**										
10							8.2	18.5										
20							8.2	18.3										
30							8.2	18.2										
40							8.2	18.1										
50							8.2	17.9										
60							8.2	17.7										
70							8.2	17.6										
80							8.2	17.6										
90							8.2	17.6										
100							8.2	17.6										
110							8.2	17.6										
120																		
130																		
140																		

Salt-diffusion of pond No.4 within a depth range of 1.1m finished in 63 days

Analysis on experimental results:

1). The No.7 pond was 10000^{m2}. The salinity of surface water is 0.8 ‰. The salinity of bottom water was 4.0 ‰. The depth of water of initial pond was 1.1m. The maximum temperature during the freezing period was 9.6 ℃. Due to evaporation and infiltration, on March 14, the water depth was down to 0.9m and completed proliferation in 22days. Stable salinity is 1.0 ‰. The temperature of the upper water was 7.9 ℃. The lower was 7.5 ℃.

2). The No.1 pond was 5000 ㎡. The salinity of upper water was 1.1 ‰. The salinity of bottom water was 17.2 ‰. The initial depth was 1.4m. Due to evaporation and underground infiltration, the depth was down to 1.1m, which lasted 30 days. After the complete proliferation of the upper and lower water, the stable salinity was 1.5 ‰. During the freezing period, the water temperature on the bottom of the pond was about 10 ℃ higher than the temperature of the natural environment.

3）.The No.2 pond is 5000 m^2. The salinity of surface water was 1.3 ‰. The salinity of bottom water 9.6 ‰. The depth of initial water was 1.2m. The maximum operating temperature during freezing period was 9.1 ℃, which lasted 30 days. On March 14th, completed proliferationin the depth of 0.8m. The stable salinity was 3.1 ‰. The water temperature was 10.3 ℃.

4）.The No.8 pond was 10,000 m^2. The surface salinity was 0.8 ‰. The bottom salinity was 5.1 ‰; the initial depth was 1.2m. The maximum operating temperature during freezing period was 10.1 ℃. On March 14th, completed proliferationin the depth of 1.0m, this lasted for 30 days. The stable salinity was 1.2 ‰. The water temperature was 0.1 to 10.6 ℃.

5）. The No.9 pond was 10,000 m^2. The salinity of surface water is 0.8 ‰. The salinity of bottom water was 6.4 ‰. The initial depth was 1.4m. The maximum temperature during the freezing period was 1.4 ℃. On March 22nd, it completed proliferationin the depth of 1.2m, which lasted 38 days. The stable salinity was 1.5 ‰. The water temperature was 10.4 ℃.

6）. The No.3 pond was 5000 ㎡. The surface salinity was 1.4 ‰. The stable salinity of bottom water was 8.0 ‰. The initial water depth was 1.m. The maximum temperature during freezing period was 9.1. On March 30th, completed proliferationin the depth ofin 1.1mn, which lasted 46 days. The stable salinity was 3.1 ‰. The water temperature was 10.4.

7）. The No.5 pond was 1000 ㎡. The surface salinity was 6.6 ‰. The bottom salinity was 21.2 ‰. The initial depth was 1.4m. The maximum freezing temperature was 11.4 ℃, the maximum temperature with gradient running was 15.4 ℃. On April 9th, completed proliferationin the water depth of 1.1m, which lasted 55 days. The stable salinity was 16.7 ‰. The water temperature was 15.3 ℃.

8）. The No.6 pond was 1000 ㎡. The surface salinity was 1.3 ‰. The bottom salinity was 7.9 ‰, the initial depth was 1.40m, the maximum operating temperature during freezing period was 11.6 ℃, the maximum temperature with gradient running was 13.3 ℃. On April 9th, completed proliferationin the water depth of 1.0m, which lasted 55 days. The stable salinity was 4.4 ‰. The water temperature was 15.2 ℃.

9）. The No.4 pond was 5000 ㎡. The surface salinity was 1.5 ‰. The bottom salinity was 17.7 ‰. The initial depth was 1.2m, the maximum operating temperature during freezing period was 13.4 ℃. On April 17th, it completed proliferation in the depth of 1.1m, which lasted for 63 days. The stable salinity was 8.2 ‰. The water temperature was 17.65℃ to19.2 ℃.

We find from the analysis on the above experimental data:

1）. Operation cycle of the non-saturated solar pond has the relationship with the depth, salinity and the thickness of the freshwater layer. The maximum operating temperature of bottom water increases along with the increasing of the depth of pond, the salinity and the thickness of gradient layer.

2.）In a natural state, non-saturated solar pond running from gradient to zero-gradient is a difficult and slow process. if the bottom was uneven, diffusion has evidently lagged far behind, such as the No.4 pond with the depth of 5000 ㎡.

Results warning:

1）. The above experiments inspire us that in aquaculture sector by using the solar pond of sea water and shallow geothermal integrated engineering technology will heat the low-temperature sea water up to 8-18℃ ao as to carry out factory aquaculture of sea cucumber. And its advantages are energy-saving and efficient.

2）. The warning of negative effects; in early spring, if use the salty ponds to breed shrimp, shellfish, sea cucumber, abalones and other species, we must firstly destroy the gradient in the ponds, or water body in the ponds can not convert from top to bottom due to the gradient. Harmful gases accumulated and zero - dissolved oxygen in the bottom can lead to the failure of the breeding.

*2.5.*Research on zero-gradient running method of unsaturated solar pond

In summer and autumn, due to gradient caused by raining, in breeding ponds of coastal areas the phenomenon of negative effects of solar pond often occurs, which bring significant economic loss for owners. How to quickly destroy a large area of gradient layers in solar ponds is a key technology problem to be solved in the field of solar pond engineering.

2.5.1 Spray experiments for spoiling gradient

In the wild natural state, design three groups of experimental ponds with the depth of 80cm, the area of 0.4m^2. Every group has 17 ponds. The salinity of the 17 ponds successively are 1‰，2‰，3‰，4‰，5‰，6‰，7‰，8‰，9‰，10‰，15‰，20‰，25‰，35‰，40‰，50‰. Inpour 5cm fresh water to the surface of experimental ponds in group A. Inpour 10cm fresh water to the surface of experimental ponds in group B. Inpour 15cm fresh water to the surface of experimental ponds in group C.Respectively install 3 pumps with the same power on the bottom of the ponds in every group. Pump salt water with high salinity of the bottom into the surface to form forcing convection from top to down, which can rapidly destroy gradient. The results will show on chart 2-14 on damage rate of spraying gradient.

Analysis on the results:

Data from the charts show that the depth of fresh water layer of four ponds in group A, of which the salinity respectively are 30 ‰, 35 ‰, 40 ‰, 50 ‰ is 5cm. The depth of fresh water layer of ponds with the same salinity in group B is 10cm. Under the same power, the experimental results will be that group A ahead of group B to achieve zero-gradient. However, the results are contrast. Through the inspections and analysis, there are uneven places on the bottom of experimental ponds, which seriously affected the efficiency of forcing convection for achieving zero-gradient.

The phenomenon warns that after heavy rain, for the aquaculture in sea and salt water, the flat bottom is an important condition for destroying gradient layers. Otherwise, if the bottom has large differences in the depth, time of deep region for achieving zero gradients will lag behind shallow region, and it may result in the local water environment of pond deteriorate, and trigger disease risk of breeding objects. Aquaculture owners will have different levels of economic loss.

2.5.2 Water flow experiment for destroying gradient

As noted above, there are 6 groups of experimental ponds with the salinity respectively are 1‰，2‰，3‰，4‰，5‰，6‰，7‰，8‰，9‰，10‰，15‰，20‰，25‰，35‰，40‰，50‰. Every three ponds with the same salinity become a group. Inpour 5cm fresh water into group A and 10cm to group B. Install pumps with the same power on the upper, middle and bottom of every pond and form series advection forced circulation in order to achieve the purpose of spoiling gradient fast.

The results show that under the condition of a flat bottom, the water flow can also fast destroy gradient layer. See the details in the damage rate chart of water flowing for destroying gradient 2-15.

2.5.3 Research on the Infiltration for destroying gradient

To overcome the shortcomings of the two above-mentioned kinds of experiments and realize more, faster, better and cheaper zero-gradient running of solar ponds. We implement the research on infiltration method for destroying gradient based on the fully investigation into the geological structure of base.

Implementation method: drill wells by ponds. Use pumps to force water to circulate ao as to mix water in the bottom with water in the surface, which can realize complete zero-gradient running of the ponds.

Inspired by the above three experiments, we put forward the theory of zero-gradient running of solar ponds and invent the zero-gradient running methods of solar ponds.

2.6 Zero gradient running case

After heavy rain, realizing zero-gradient running in small ponds can be easily controlled by learning from the above simulation results. However, in dozens of acres, hundreds of acres or even thousands of acres of uneven ponds, quickly achieving zero-gradient running is a very large and difficult engineering technology. In such case, based on fully investigation into regional resources, correctly choose combining points to expand experiment scale. We initially gain three innovative achievements

.

2.6.1Water flowing experiment for destroying gradient

Rebuild 2000m^2 turbot aquaculture workshops and drill four supporting wells. Connect 10 shrimp ponds in series, in total of 70,000 ㎡. Breed 20,000 turbots in aquaculture workshop of 2,000 ㎡ . Breed 40,000 shrimp babies every mu. Wells sheds and ponds connected in series operate around the clock for 30 months. During the 30 months, the water flow is 80m^3/h. regularly test physical and chemical indicators of water quality. We find that all

2-14 Damage Rate Chart Of Spray for Destroying Gradient

Shallow Layer	ppt / Parameters	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	50
Group A 5cm	Temperature	27.5	27.6	27.6	27.8	27.9	28.2	28.3	28.3	28.0	28.0	27.9	27.8	27.8	27.9	27.7	27.7	27.5
	Salinity	0.9	1.9	2.9	3.9	4.8	5.7	6.7	7.7	8.6	9.5	14.2	19.0	23.4	28.3	33.5	37.5	46.8
	Diffusion Time	7’7”	10’15”	14’38”	15’20”	20’50”	23’18”	25’15”	28’38”	32’53”	34’19”	35’58”	38’33”	41’21”	46’30”	59’14”	61’01”	82’18”
Group B 10cm	Temperature	28.8	28.9	28.5	28.5	28.6	28.7	29.0	29.5	29.3	29.5	28.9	28.8	28.4	27.9	27.8	27.5	27.6
	Salinity	0.9	1.8	2.7	3.6	4.5	5.4	6.3	6.9	8.0	8.9	13.4	17.9	22.6	26.7	31.1	37.8	44.4
	Diffusion Time	7’54”	13’16”	14’35”	22’28”	34’40”	35’52”	36’35”	37’	39’45”	42’50”	43’45”	44’10”	46’10”	51’10”	51’30”	54’40”	80’05”
Group C 15cm	Temperature	27.4	27.6	28.1	28.2	28.8	29.0	29.8	28.7	28.0	27.7	27.4	24.1	30.4	29.5	28.9	27.9	27.4
	Salinity	0.9	1.7	2.5	3.4	4.1	4.9	5.8	6.6	7.4	8.4	12.5	16.3	20.6	24.6	28.6	32.7	40.9
	Diffusion Time	9’48”	19’13”	28’07”	28’55”	36’30”	36’50”	38’19”	39’30”	41’10”	43’05	44’45”	45’24”	50’29”	52’50”	54’	57’23”	62’38”

Note: pumping capacity of pumps is 3.21kg per minute, 192.6kg per hour. (The salinity is 25‰)
Height of experimental ponds is 80cm. Diameter is 60cm. Volume is 0.22608m$^{3.}$

2-15 Damage Rate Chart of Water Flow for Destroying Gradient

Shallow Layer	ppt / Parameters	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	50
Group A 5cm	Temperature	26.3	26.2	26.0	25.7	25.7	25.7	25.7	25.7	22.5	22.6	23.8	26.0	26.5	26.3	26.9	27.1	27.0
	Salinity	0.9	1.8	2.8	3.8	4.8	5.8	6.8	7.8	8.7	9.6	14.5	19.2	24.1	28.7	33.5	38.6	47.0
	Time	2’	5’35”	8’26”	9’19”	11’11”	12’24”	14’24”	15’21”	16’20”	17’35”	18’38”	25’10”	25’45”	28’55”	37’27”	52’28”	57’46”
Group B 10cm	Temperature	19.0	19.1	18.7	18.9	19.7	19.6	19.7	19.4	20.0	19.8	19.6	16.1	16.1	16.0	16.5	17.1	17.0
	Salinity	0.9	1.8	2.7	3.5	4.4	5.3	6.1	7.0	7.9	8.8	13.2	17.6	22.1	26.2	31.8	37.8	43.3
	Time	5’42”	10’14”	11’41”	12’28”	14’52”	18’30”	18’54”	19’03”	21’52”	23’57”	26’42”	36’40”	46’41”	48’17”	50’42”	54’48”	80’10”

Note: flow in the upper, middle and lower layer per minute is 9.69kg. (581.4kg/h) indicators comply with the technical indicator for healthy aquaculture. (See chart of 2-16, 17, and 18). We successfully finish zero-gradient running experiment in large ponds and harvest 20,000 kilograms of turbots and 100,000 kilograms of shrimps. Achieve double-harvest both on academic research and production development.

Paraneters for Solar Pond Zero-Gradient Running

Chart 2-16 Aug. 20th No. 10 pond 10,000m^2

Depth (cm)	Temperature (℃)	Salinity ppt	Do (mg/l)	PH Value	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S (mg/l)	CoD (mg/l)	BoD (mg/l)
0	26.5	23.2	9.0	8.0	0.33	0.05	0.01	7.0	3.2
20	26.3	23.2	9.0	8.0					
40	26.0	23.2	8.7	8.0					
60	25.7	23.2	8.6	7.8					
80	25.5	23.2	8.5	7.8	0.33	0.05	0.01	8.5	3.5
100	25.5	23.2	8.4	7.8					
120	25.5	23.2	8.1	7.8					
140	25.5	23.2	8.1	7.8					
160	25.5	23.2	8.1	7.8					
180	25.5	23.2	8.1	7.8	0.36	0.06	0.01	9.0	3.6

Paraneters for Solar Pond Zero-Gradient Running

Chart 2-17 Aug. 20th No. 10 pond 10,000 m^2

Depth (cm)	Temperature (℃)	Salinity ppt	Do (mg/l)	PH Value	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S (mg/l)	CoD (mg/l)	BoD (mg/l)
0	25.5	23.1	11.7	8.5	0.29	0.03	0.01	7.5	3.2
20	24.8	23.1	11.0	8.5					
40	24.5	23.1	10.8	8.5					
60	24.0	23.1	10.8	8.5					
80	23.8	23.1	10.8	8.4					
100	23.0	23.1	10.8	8.4					
120	23.0	23.1	10.8	8.3					
140	23.0	23.1	10.8	8.3					
160	23.0	23.1	10.5	8.3	0.29	0.05	0.01	9.5	3.5
180	23.0	23.1	10.3	8.3					
200	23.0	23.1	10.0	8.3					
220	23.0	23.1	9.8	8.3					
240	23.0	23.1	9.8	8.3					
260	23.0	23.1	9.8	8.3					
280	23.0	23.1	9.8	8.3					
300	23.0	23.1	9.8	8.3	0.34	0.08	0.01	10.5	3.6

Paraneters for Solar Pond Zero-Gradient Running

Table 2-18 Aug. 20th No. 1 pond 10,000m^2

Depth (cm)	Temperature (℃)	Salinity ppt	Do (mg/l)	PH	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S (mg/l)	CoD (mg/l)	BoD (mg/l)
0	21.0	23.0	8.8	7.7	0.28	0.04	0.01	7.5	3.1
20	20.5	23.0	8.5	7.7					
40	20.3	23.0	8.4	7.7					
60	20.3	23.0	8.4	7.7					
80	20.3	23.0	8.4	7.7					
100	20.3	23.0	8.4	7.7	0.29	0.04	0.01	8.0	3.3
120	20.3	23.0	8.4	7.5					
140	20.3	23.0	8.4	7.5					
160	20.3	23.0	8.0	7.5					
180	20.3	23.0	8.0	7.5					
200	20.3	23.0	7.8	7.5	0.30	0.05	0.01	10.5	3.5

2.6.2 Aeration jetting for more oxygen destroying gradient

Install 20 pump water aerobic equipments, of which the powers are 3kw, 5.5kw, 4kw and 1.5kw in the four 10000m^2 and two 5000m^2 ponds with low salinity. Carry out zero-gradient running experiment for two cycle periods. Every physical and chemical parameter is completely controlled in indicators referred in the contract. (See the chart of 2.19-2.24). We achieve encouraging research results, end-shrimp aquaculture products, which pass the security check on non-pollution and zero-drug for shrimps implemented by Ministry of Agriculture.

Parameters for Solar Pond Zero-Gradient Running

Chart 2-19 Jul. 28th 5,000m^2

Depth (cm)	Temp. (℃)	Salinity ppt	Mineral content	Do (mg/l)	PH	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S (mg/l)	CoD (mg/l)	BoD (mg/l)
0	29.0	20.0	9261	10.0	8.7	0.31	0.005	0.001	8.0	3.6
20	28.4	20.0	9261	9.1	8.5					
40	27.4	20.0	9261	5.5	8.5					
60	27.4	20.0	9261	5.5	8.4	0.33	0.006	0.001	13.0	3.7
80	27.3	20.0	9261	5.5	8.3					
100	27.3	20.0	9261	5.2	8.3	0.40	0.007	0.001	14.9	3.7

Parameters for Solar Pond Zero-Gradient Running

Chart 2-20 Jul. 28th 5,000m^2

Depth (cm)	Temp. (℃)	Salinity ppt	Mineral content	Do (mg/l)	PH	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S (mg/l)	CoD (mg/l)	BoD (mg/l)
0	28.7	25.1	15791	12.0	8.6	0.33	0.05	0.001	9.0	3.5
20	27.7	25.1	15791	11.1	8.5					
40	27.2	25.1	15791	9.1	8.5					
60	27.1	25.1	15791	7.8	8.4					
80	27.0	25.1	15791	7.8	8.4	0.34	0.05	0.001	11.0	3.7
100	27.0	25.1	15791	7.7	8.4					
120	27.0	25.1	15791	7.7	8.3					
140	27.0	25.1	15791	7.7	8.3					
160	27.0	25.1	15791	7.7	8.2	0.34	0.06	0.001	140	3.7

Parameters for Solar Pond Zero-Gradient Runnin

Chart 2-21 Jul. 28th 10,000m^2

Depth (cm)	Temperature (℃)	Salinity ppt	Mineral content	Do (mg/l)	PH Value	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S	CoD	BoD
0	31.6	5.0	4066	6.0	8.32	0.22	0.03	0.01	6.0	3.5
20	31.6	5.0	4052	5.7	8.32					
40	31.6	5.0	4033	5.6	8.34					
60	30.4	5.0	4005	5.6	8.34	0.22	0.03	0.01	6.6	3.6
80	30.4	5.0	4005	5.6	8.34					
100	29.9	5.0	4000	5.6	8.34	0.23	0.03	0.01	6.7	3.7

Parameters for Solar Pond Zero-Gradient Running

Chart 2-22 Jul. 28th 10,000m²

Depth (cm)	Temp. (℃)	Salinity ppt	Mineral content	Do (mg/l)	PH	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S mg/l	CoD mg/l	BoD (mg/l)
0	27.9	10.0	7947	6.1	8.32	0.31	0.06	0.01	9.5	3.5
20	27.9	10.0	7947	5.8	8.32					
40	27.9	10.0	7947	5.8	8.34					
60	27.9	10.0	7947	5.8	8.34					
80	27.9	10.0	7947	5.8	8.34	0.33	0.06	0.01	9.8	3.8
100	27.9	10.0	7947	5.8	8.34					
120	27.9	10.0	7947	5.8	8.34					
140	27.9	10.0	7947	5.8	8.34					
160	27.9	10.0	7947	5.8	8.34	0.33	0.06	0.01	11.0	3.8

Parameters for Solar Pond Zero-Gradient Running

Chart 2-23 Jul. 28th 10,000m²

Depth (cm)	Temperature (℃)	Salinity ppt	Mineral content	Do (mg/l)	PH Value	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S (mg/l)	CoD(mg/l)	BoD (mg/l)
0	29.5	15.0	12277	11.5	8.42	0.38	0.04	0.01	7.0	3.3
20	29.3	15.0	12277	10.5	8.41					
40	27.9	15.0	12277	10.5	8.38					
60	27.5	15.0	12277	10.5	8.38					
80	27.5	15.0	12277	10.5	8.38					
100	27.5	15.0	12277	10.5	8.38	0.39	0.05	0.01	8.0	3.4
120	27.5	15.0	12277	10.5	8.38					
140	27.5	15.0	12277	10.5	8.38					
160	27.5	15.0	12277	10.0	8.36					
180	27.5	15.0	12277	10.0	8.35					
200	27.4	15.0	12277	10.0	8.35	0.39	0.05	0.01	8.0	3.4

Parameters for Solar Pond Zero-Gradient Running

Chart 2-24 Jul. 28th 10,000m²

Depth (cm)	Temperature (℃)	Salinity ppt	Mineral content	Do (mg/l)	PH Value	Ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S (mg/l)	CoD (mg/l)	BoD (mg/l)
0	27.6	25.0	17859	9.1	8.21	0.32	0.06	0.01	9.5	3.5
20	27.6	25.0	17883	8.8	8.18					
40	27.5	25.0	17826	8.8	8.14					
60	27.5	25.0	17829	8.8	8.11					
80	27.5	25.0	17884	8.8	8.11					
100	27.4	25.0	17884	8.5	8.11					
120	27.4	25.0	17884	8.5	8.11					
140	27.4	25.0	17884	8.5	8.11	0.32	0.06	0.01	11.0	3.8
160	27.4	25.0	17884	8.5	8.0					
180	27.4	25.0	17884	8.5	8.0					
200	27.3	25.0	17884	8.5	8.0					
220	27.3	25.0	17884	8.5	8.0					
240	27.3	25.0	17884	8.5	8.0					
260	27.3	25.0	17884	8.5	8.0	0.33	0.06	0.01	11.0	3.9

2.6.3 Infiltration method for destroying gradient experiment

Drill four wells by the No.1 pond, No.2 pond and No.3 pond. Continuously pump underground water with pumps so that pond water and well water can form closed circulation system so as to restrain gradient effect in the pond. Physical and chemical indicators for water quality are controlled well and we achieve encouraging cycle running effects. (See chart 2-25, 2-26)

Parameters for Solar Pond Zero-Gradient Running

Chart 2-25 Jul. 20th No. 3 pond 5,000m²

Depth (cm)	Temperature (℃)	Salinity ppt	Do (mg/l)	PH	ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S (mg/)	CoD (mg/l)	BoD (mg/l)
0	23.1	23.2	7.8	7.8	0.32	0.06	0.01	7.6	3.1
20	23.0	23.2	7.5	7.8					
40	23.0	23.2	7.5	7.8					
60	23.0	23.2	7.5	7.8					
80	23.0	23.2	7.4	7.8					
100	23.0	23.2	7.4	7.8					
120	23.0	23.2	7.4	7.7					
140	23.0	23.2	7.4	7.7	0.32	0.06	0.01	9.0	3.3
160	23.0	23.2	7.4	7.7					
180	23.0	23.2	7.3	7.7					
200	23.0	23.2	7.2	7.7					
220	23.0	23.2	7.1	7.7					
240	23.0	23.2	6.8	7.7	0.34	0.07	0.01	9.5	3.6

Parameters for Solar Pond Zero-Gradient Running (Jet)

Chart 2-26 Jul. 20th No. 1 pond 5,000m²

Depth (cm)	Temperature (℃)	Salinity ppt	Do (mg/l)	PH	ammonia nitrogen (mg/l)	Nitrite (mg/l)	H_2S mg/l	CoD (mg/l)	BoD (mg/l)
0	22.8	23.0	9.8	8.3	0.28	0.03	0.01	7.0	2.7
20	22.5	23.0	9.5	8.2					
40	22.5	23.0	9.5	8.2					
60	22.5	23.0	9.5	8.2					
80	22.5	23.0	9.5	8.2					
100	22.5	23.0	9.5	8.2					
120	22.5	23.0	9.5	8.2					
140	22.5	23.0	9.5	8.2	0.29	0.03	0.01	7.5	3.0
160	22.5	23.0	9.5	8.2					
180	22.5	23.0	9.4	8.2					
200	22.5	23.0	9.3	8.2	0.30	0.04	0.01	8.0	3.1

3. Scientific and Innovation of Key Technologies

At present, in fields of solar pond engineering study, people are all for the purpose of maximally gain effects of heat collection, heat storage and heat supply of solar pond and only care about its running temperature, regardless its running situation for physical and chemical indicators in bottom convection zone. However, the zero-gradient running technology for solar pond which we invented not only studies solar pond operation mechanism and the highest running temperature in fresh and sea water sector under the natural state but also studies how to restrain negative effects of solar pond in marine aquaculture project. The zero-gradient running technology for solar pond rapidly implements zero-gradient running techniques for solar pond, which achieves around clock and high efficient application of solar pond project. Under the unger of this goal, the scientific, advancement and innovation of key technology in the study have been well reflected.

3.1 Explore salt diffusion rate for unsaturated solar pond and invent solar pond for refrigerating temperature method

In the period of 8 months for collecting parameters of temperature and salinity, we accidently find that experimental pond having light can be heated up and having no light can control temperature. The result can be widely applied for controlling water temperature in sea cucumber factory aquaculture and pro-body spring protection seeds task.

3.2 Explore the thermal stability of the solar pond and invent high efficiency method for heat utilization of solar pond

For non-saturated solar pond experiment outdoors, due to the built-in bag, experimental vessel, leaked and the bag drifted upward 40cm. Therefore it was in need of replacement and rejection of liquid. During that period, we accidentally find that after running for 15 days the water in the bottom of the pond still remain the initial salinity and the liquid which drifted upward had completed proliferation. Inspired by this phenomenon, we invent high efficiency method for heat utilization of solar pond. This experiment proves that in coastal areas as long as the sun, land, marine and fresh water, we can produce thermal energy at any time.

3.3 Study zero- gradient scophthalmus maximums and shrimp farming methods and invent residential heating and electricity heating methods

In the zero- gradient running experiments for large-scale solar pond, healthy breaded scophthalmus maximums and shrimp for 36 months the temperature of the well kept between 13.5 to 17.5℃ throughout the year. In this background, we invented rural residential solar pond, Fresnel lens and shallow wells integrated running method.

3.4 Explore the micro-ecosystem of solar pond and integrated running zero-gradient program for water purification

Running technology of zero-gradient solar pond can overcome the negative effects of solar pond ,but can not repair the deteriorating water environment, especially molecule water group. In order to solve this problem, we creatively adopt interaction among mioroalgae, certain bacteria and photocatalytic process. We successfully transfer the metabolites, residual feed and floating animal and plant debris of farming objects into nutrients, thereby improve the water quality and create fine pond ecosystem suitable for the healthy growth of farming objects.

3.5 Innovation of theoretical research

3.5.1 Mathematical model of one-dimensional proliferation

In the study field of non-saturated solar pond, we establish mathematical model of one-dimensional proliferation for the first time which can accurately describe the distribution of the salinity. The model provides strong theoretical support for the results salt proliferation indoor ponds.

3.5.2 Algebraic equations

According to the basic idea of Data on heat transformation, we establish the algebraic equations between variables under the complex system of outdoor’s non-saturated solar pond for the first time.

3.5.3 Expert System

Based on the above-mentioned experiments, we develop simulation software for non-saturated solar pond and initially complete expert systems for non-saturated solar pond running.

3.5.4 Running theory of zero-gradient solar pond

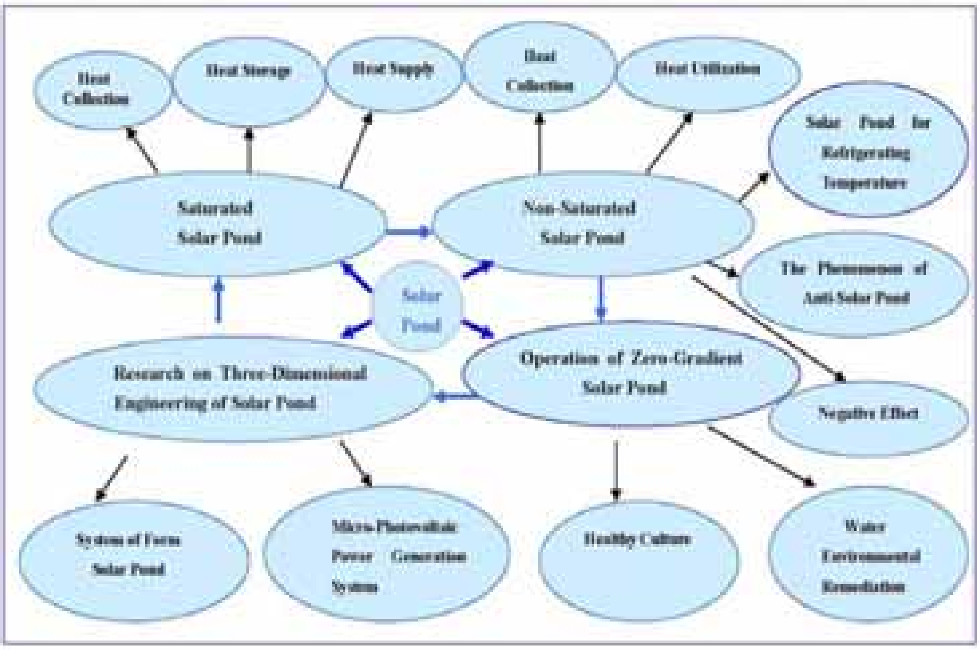
In the difficult outdoor's solar pond experiments, we collected a large number original parameters for non-saturated solar pond running and recognize foramtion causes of natural non-saturated soalr pond and the devastating effects on fish production. On this basis, we propose zero-gradient running theory of non-saturated solar pond. The achievements have a profound impact on China's marine aquaculture industry and even the world's marine aquaculture industry.

3.5.5 Application of three-dimensional space theory for solar pond

In the experiment of thermal stability of solar pond, when the salt dissoluted in the water, the property that water is a poor conductor of heat is unalterable. Inspired by this phenomenon, we propose application of three-dimensional space theory for solar pond and invented solar pond window and photovoltaic window of solar pond.

3.8 Established research and development road map for solar pond engineering

In the long-term field experiments and the guidance of new theoretical system of solar pond , we develop the solar pond engineering study from the study on the traditional saturated solar pond running technology to the study on non-saturated solar pond running techniques; from the study on the thermal stability of non-saturated solar pond to the study on running method for zero-gradient solar pond; from the study on the running mechanism of zero-gradient solar pond to the study on the three-dimensional engineering of solar pond. (See the table 3-1). The outcome of the subject represents the lasted study direction of the world's solar pond area.



References

Jinlong Cao 2007.Study on Technique for Integrated Heating of a Solar Pond. Solar Energy And Human Settlement. Volume IV. 2138-2150.

Jimmy Leblanc 2007. Low-Temperature Multi-Effect Evaporation Desalination Systems

Coupled with Salinity—Gradient Solae Ponds. Solar Energy And Human Settlement. Volume IV.2151—2157.
Yuchun Zhao.Aliakbar Akbarzadeh.2007. Combined Water Desalination and Power Generation Using a Salinity Gradient Solar Pond as a Renewable Energy Source. Solar Energy And Human Settlement. Volume IV.2184--2188.