Salt Partners

Feedstock focus: Understanding the importance of chloralkali to the salt industry

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20th World Chloralkali Conference, 16.–17.6.2016, Millennium Hilton, Bangkok

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Salt Production World-wide

Salt type	World production
Solar salt	120,000,000 t/y
Rock salt	80,000,000 t/y
Brines	100,000,000 t/y
Total	300,000,000 t/y

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Salt Consumption World-wide

Salt user	Salt consumption
Chemical industry	180,000,000 t/y
Food	30,000,000 t/y
De-icing	40,000,000 t/y
Other	50,000,000 t/y
Total	300,000,000 t/y

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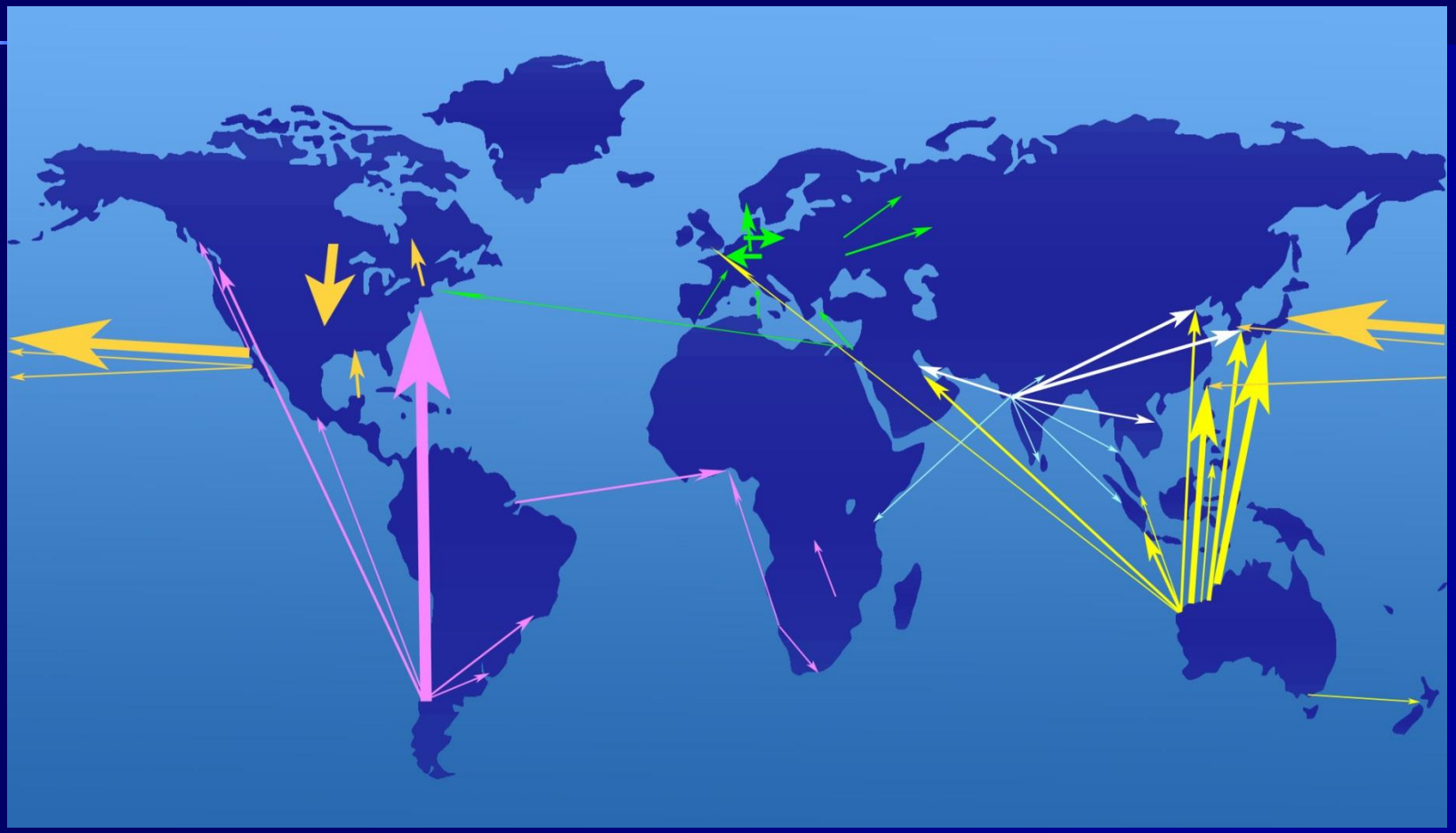
World Bulk Salt Trade



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Flight over Australian Saltfields

In 2009 Salt Partners flew over some of the world largest solar saltfields. Isabella Sedivy was shooting pictures.

GOOGLE EARTH

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Shark Bay Salt Stockpiles

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The Shark Bay stockpiles are 200m long and 60m wide. Their design capacity is 250’000 t. In 2009 they were less than half full.

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Shark Bay Salt Stockpiles

In November 2015, viewed on Google Earth, the Shark Bay stockpiles were still less than half full.

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Lake McLeod Salt Stockpile

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At Lake McLeod, the stockpile next to the wash plant has a design capacity of 1’500’000 t. In 2009 it was about 12% full.

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Lake McLeod Salt Stockpile

Also the Lake McLeod stockpile pictured in October 2015 didn't show much change.

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Onslow Salt Stockpile

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Onslow stockpile was designed for 500‘000 t of salt. On 2.2.2009, there was virtually no salt left. The picture shows the shipment of last salt from Onslow stockpile.

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Onslow Crystallisers

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On 27.1.2009 the Onslow saltworks were flooded by cyclone Dominic.

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Onslow Brine Pond No. 1

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Onslow brine pond one week after it was hit by the cyclone Dominic. The dikes were broken through at three locations. Brine was flowing out, to the sea. It took many months to restore full production.

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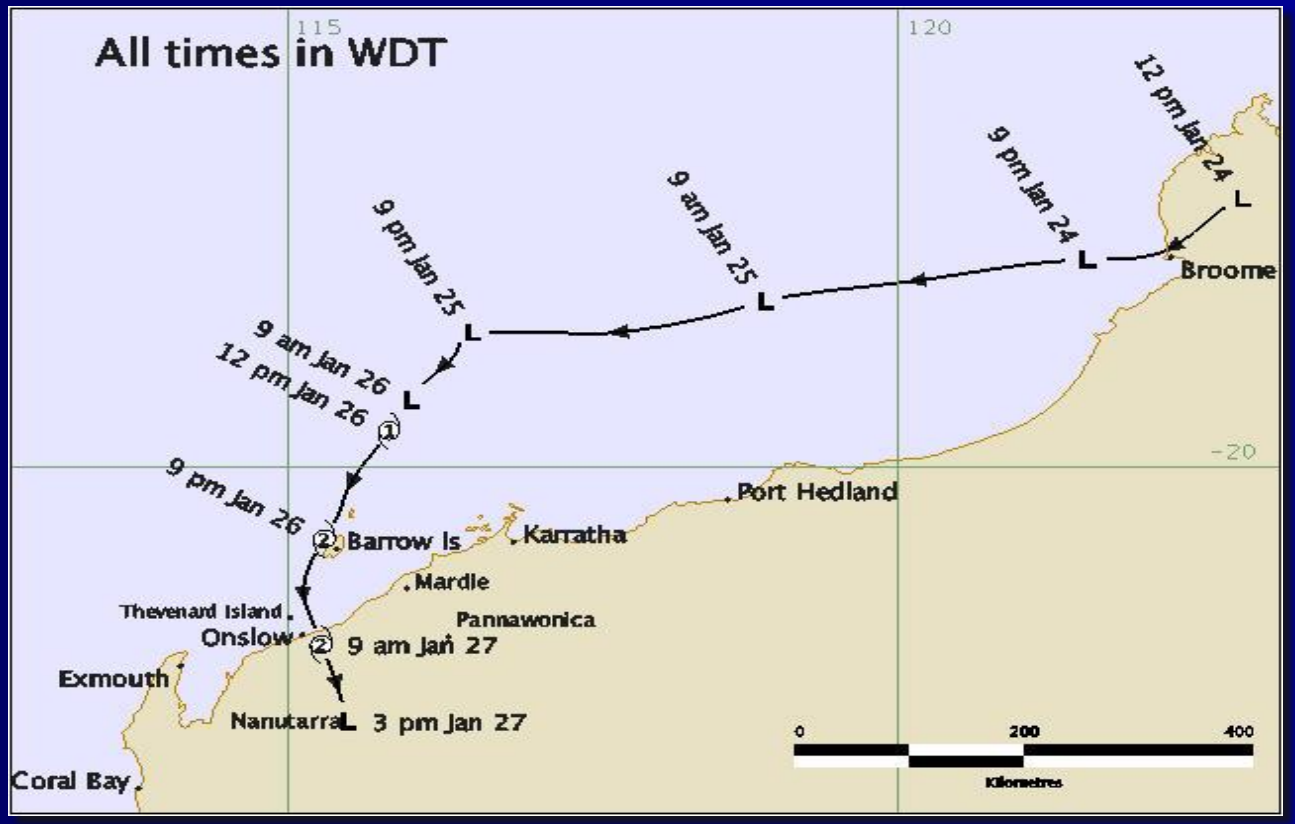
Tropical Cyclone Dominic



Australian Bureau of Meteorology

The Onslow saltfield was hit by tropical cyclone Dominic on 27.1.2009. Dominic was a moderate, category 2 cyclone with wind gust 140 km/h and 240 mm rainfall.

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Onslow Salt Stockpile

This Google Earth image from May 2016 shows Onslow stockpile about 25% full.

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Dampier Original Drying Stockpile

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At Dampier, the original drying stockpile was designed for up to 2’000’000 t. It is not being used any more. Harvested salt is hauled to the new washing plant near the sea shore.

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Dampier Original Intermediate Stockpile

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The two Dampier original intermediate stockpiles are now used to dry the salt washed in a new washing plant. They are 400 m long and 55 m wide. They can hold up to 500’000 t. In 2009 the pictured stock was estimated at about 170’000 t or 36% of design capacity.

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Dampier Original Intermediate Stockpile

The Google Earth image from October 2015 shows Dampier intermediate stockpile almost empty.

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Dampier Shipping Stockpile

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Dampier shipping stockpile could hold more than 250’000 t. The picture from 2009 shows less than100’000 t of salt ready for shipment.

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Dampier Shipping Stockpile

This Google Earth image from May 2016 shows unchanged situation at the Dampier salt shipping stockpile.

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Port Headland Stockpiles

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Port Headland stockpiles are large enough to hold about 1’400’000 t. In February 2009, they were less than 60% full.

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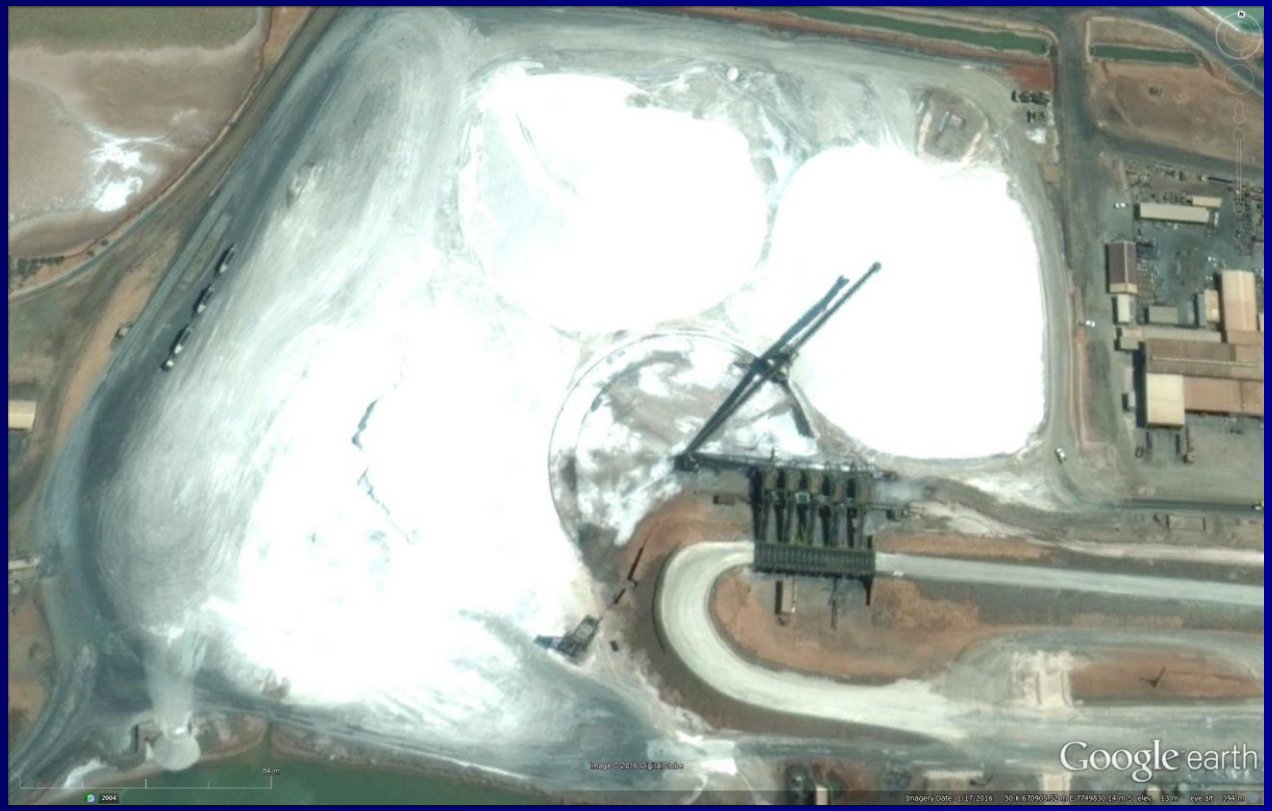
Port Headland Stockpiles



This Google Earth image from January 2016 shows Port Headland stockpile to be about 40% full.

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Australian Salt Stockpiles in February 2009

Salt Producer	Stockpile	Stockpile Capacity	Salt on Stock	Percent Full
		(t)	(t)	(%)
Shark Bay		275‘000	133‘000	48%
Onslow		652‘000	1‘000	0%
McLeod	Drying	1'520‘000	180‘000	12%
	Shipping	267‘000	7‘000	3%
Dampier	Drying	1'896‘000	0	0%
	Intermediate	475‘000	169‘000	36%
	Shipping	264‘000	96‘000	36%
Port Headland	Drying	999‘000	567‘000	57%
	Shipping	384‘000	199‘000	52%
Total		**6'732‘000**	**1'352'000**	**20%**

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Australian Salt Production Capacity and Design Stockpiling Capacity

Salt Producer	Production Capacity	Stockpiling Capacity	Percent
	(t/y)	(t)	(%)
Shark Bay	2’200’000	275’000	13%
Onslow	2’500’000	653’000	26%
McLeod	2’300’000	1’787’000	78%
Dampier	4’000’000	2’635’000	66%
Port Headland	3’500’000	1’384’000	40%
Total	**14’500’000**	**6’734’000**	**46%**

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Australian Salt Production Capacity and Salt on Stockpile

Salt Producer	Production Capacity	Salt on Stockpile	Percent
	(t/y)	(t)	(%)
Shark Bay	2’200’000	133’000	6%
Onslow	2’500’000	1’000	0%
McLeod	2’300’000	187’000	8%
Dampier	4’000’000	264’000	7%
Port Headland	3’500’000	765’000	2%
Total	**14’500’000**	**1’352’000**	**9%**

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Drip-off Belts

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Most Australian wash plants employ drip-off belts. This picture shows that at the end of such belt, the salt is still dripping wet.

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Salt Drying on Stockpiles

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Drip-dried salt is wet when stockpiled. The brine flows slowly to the ground and out of the stockpile (see bottom left).

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Salt on Stockpile, Humidity vs. Time

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Magnesium salts are hygroscopic. They absorb moisture from the air. The brine so formed dilutes the magnesium. As long as the salt is more than 3% humid, the brine flows with the magnesium out of the stockpile. After the magnesium is removed, the salt can dry up. The drying process takes about 3 months.

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Residual Magnesium in Salt after Washing

- **Magnesium in bitterns: 2.64%**
- **Magnesium in 10% humid salt after harvest: 0.26%**
- **Magnesium in sea water: 0.14%**
- **Standard magnesium content in salt: 0.02%**

Washing with sea water	Magnesium in 10% humid salt	Magnesium in 2.5% humid salt	Salt losses by dissolution
(l/t of salt)	(%)	(%)	(%)
100	**0.139**	**0.035**	**3**
200	**0.097**	**0.024**	**7**
300	**0.076**	**0.019**	**10**

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Consequences of Insufficient Salt Stock on Stockpile

- Insufficient reserve to overcome temporary production shortage
- Excessive humidity and magnesium, salt not up to specification
- Higher wash water consumption, thus excessive salt losses
- Reduced production rate

Insufficient Salt Stock is Undesirable

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Remedy Option No.1:

Compensate shortage with poor quality salt

This option is undesirable:

- **Impurities increase the cost of brine treatment in chloralkali plants**
- **Poor quality salts cause excessive contaminated effluent discharge**

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General Cost of Salt and Impurity Removal

	Cost of brine treatment and sludge disposal	Cost of salt, brine treatment and sludge disposal
	(USD / t salt)	(USD / t salt)
Minimum	**1.50**	**10**
Average	**10**	**25**
Maximum	**30**	**50**

SALT PARTNERS AT GANDHIDHAM 2008 SALT CONFERENCE

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Remedy Option No. 2

Compensate shortage with vacuum salt

This option is undesirable:

- **Vacuum salt is expensive**
- **Vacuum salt production is mostly energy inefficient**
- **1 ton of CO_2 per ton of salt may emanate when burning black coal**
- **Burning black coal frequently causes pollution**
- **CO_2 in the atmosphere causes global warming and climatic change**

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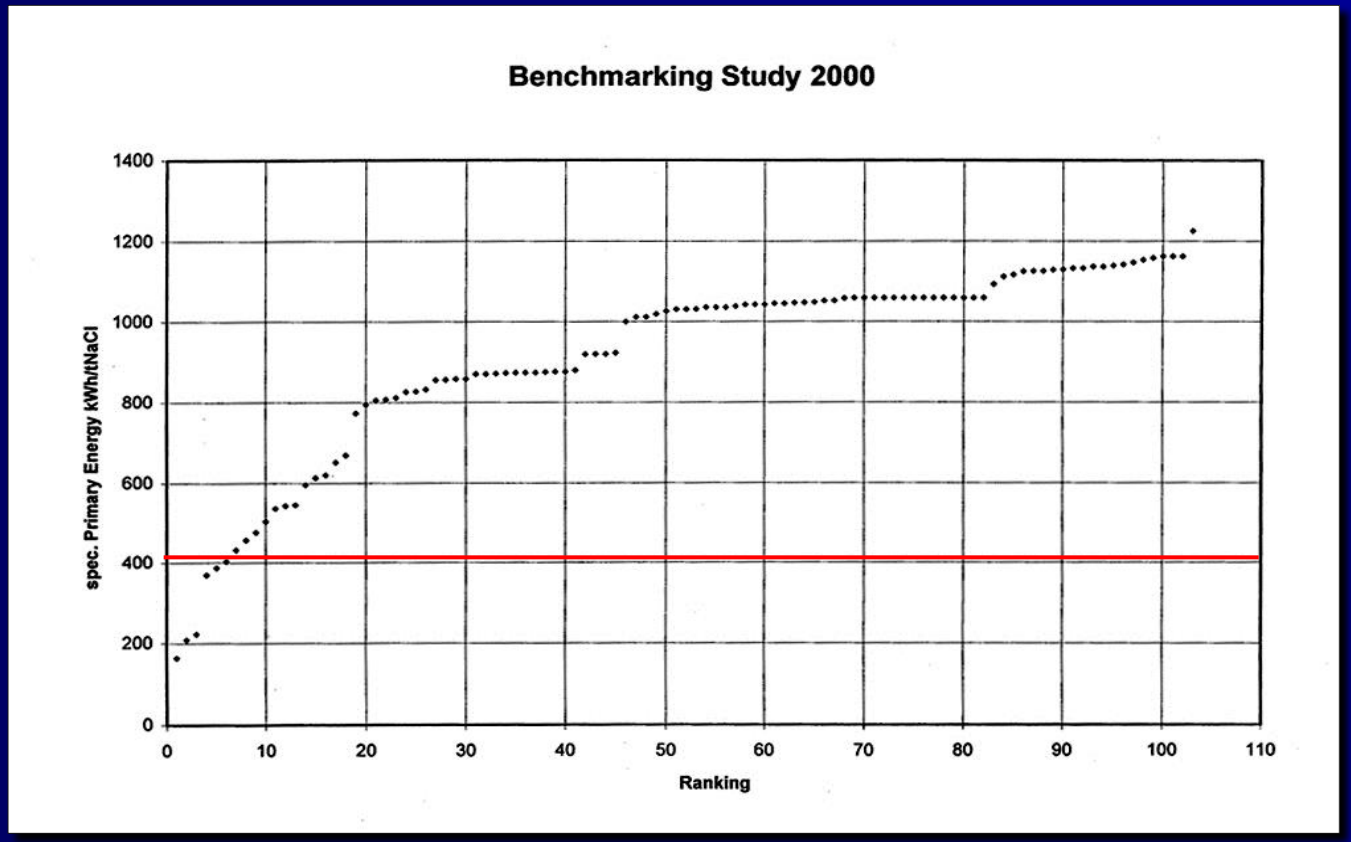
Energy Consumption Benchmarking Study



96 out of 103 thermal salt evaporating plants use more than theoretical amount of energy.

EVATHERM

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Air Pollution

WU HONG / EPA

In China, black coal is burned to make steam for vacuum salt production.

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Global Warming

NASA

Hurricane "Katrina" in the Gulf of Mexico on 29.8.2005.

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Destructive Climatic Change

Groenteman

Hurricane “Katrina” destroyed large parts of New Orleans and surroundings. Increased hurricane activity is believed to be caused by global warming.

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Remedy Option No. 3

Compensate shortage with additional high quality solar salt production capacities

This option is highly desirable:

- **High quality solar salt is inexpensive**
- **Solar salt production employs renewable energy most effectively**
- **Solar saltfields are environmentally beneficial wetlands**

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Chinese Solar Salt Production Method

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At the Gulf of Bohai, sudden rain storms are frequent and heavy. Saturated brine is being protected against dilution with plastic foils. The plastic is pulled over the brine, rain water is drained when the storm is over and the plastic foil is rolled back using electric motors.

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Chinese Salt Production Method is Labour Intensive

Large workforce is required to live inside the saltworks to pull the plastic quickly, within an hour of the storm warning and drain the rain water when the storm is over. How long will the workforce be available at the present low cost?

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Australian and Chinese Saltworks Productivity

Salt Producer	Production Capacity	Saltworks Area	Productivity
	(t/y)	(km2)	(t/km2)
Shark Bay	2’200’000	70	31’400
Onslow	2’500’000	86	29’000
Dampier	4’000’000	100	40’000
Port Headland	3’500’000	92	38’300
Hangu Changlu	1’000’000	135	7’400

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Solar Salt Production in the North of Bohai Gulf

Two major Tianjin saltworks occupy approx. 400 km2 of land adjacent to the booming TEDA (Tanggu Economic Development Area).

To the north of TEDA, the Hangu Changlu Saltern produces 1’000’000 t/y of solar salt on135 km2 of land.

In the middle, one of the largest Chinese ports is being developed.

Saltworks land in the south of TEDA, next to the harbour, has already been converted to a coal storage (see the black spot).

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Conversion of Solar Saltworks to Industrial Parks

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Parts of the Hangu Changlu Saltern have already been converted to an industrial park.

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Conclusion

Solar salt production in the Gulf of Bohai has a limited future potential:

- **Present production method is too labour intensive**
- **Climatic conditions are unfavourable**
- **Land is required for more productive use**

High quality solar salt should be produced in more suitable regions more efficiently and imported to China.

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Opportunity for Solar Salt Exports

Solar salt exports could fill the gap if:

- **Quality according to the "Australian standard", i.e. less than 0.04% Ca, 0.02% Mg and 0.12% SO4 would consistently be achieved**
- **Shipments in Panamax vessels would be possible**
- **Ship loading rates of 2'000 t/h would be facilitated**

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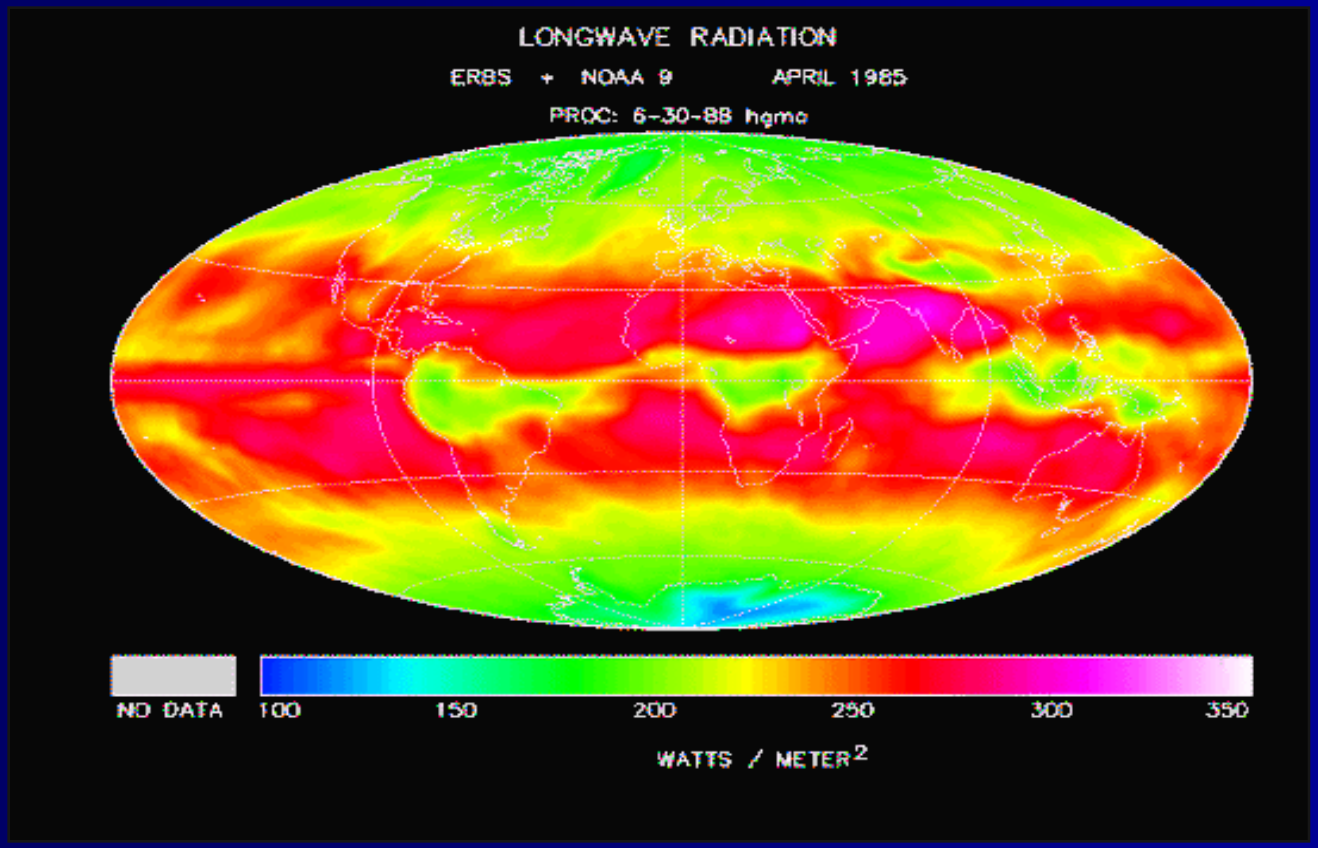
Solar Energy on the Planet Earth



NASA

Locations with highest rates of evaporation, suitable for solar salt production:

Caribbean Sea
North Africa
South Africa
Middle East
Western India
Western Australia

In China, the Gulf of Bohai receives only half the solar energy available at the most suitable locations.

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New Developments in India

New developments are taking place in the Indian solar salt sector in the hot and arid state of Gujarat.

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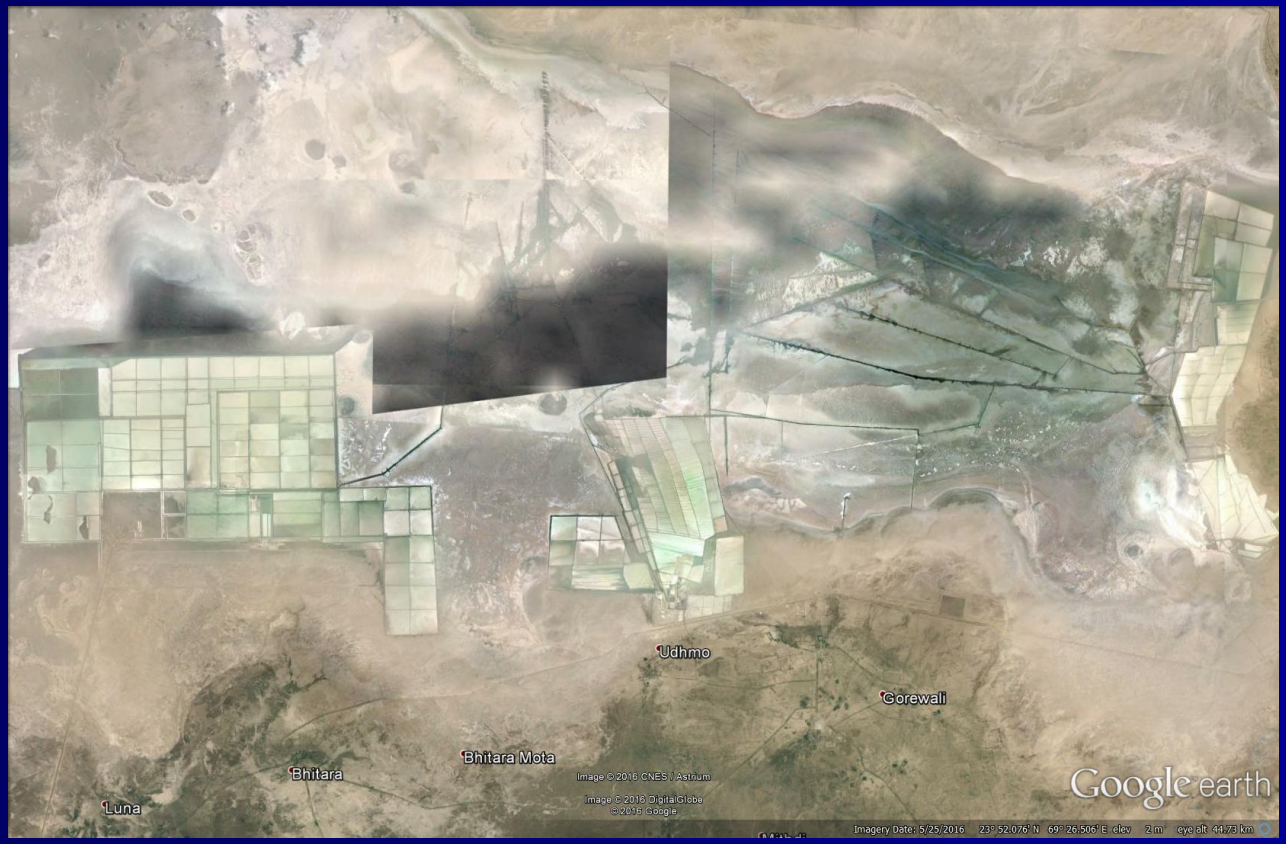
New Indian Solar Saltworks



This Google Earth image from May 2016 shows new Indian solar saltworks on the border to Pakistan.

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Jakhau Solar Saltworks

Jakhau solar saltworks and salt export terminal.

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Jakhau Salt Export Terminal

The Jakhau salt export terminal is located near shallow waters. Barges transport the salt to the Handysize vessels in the open sea.

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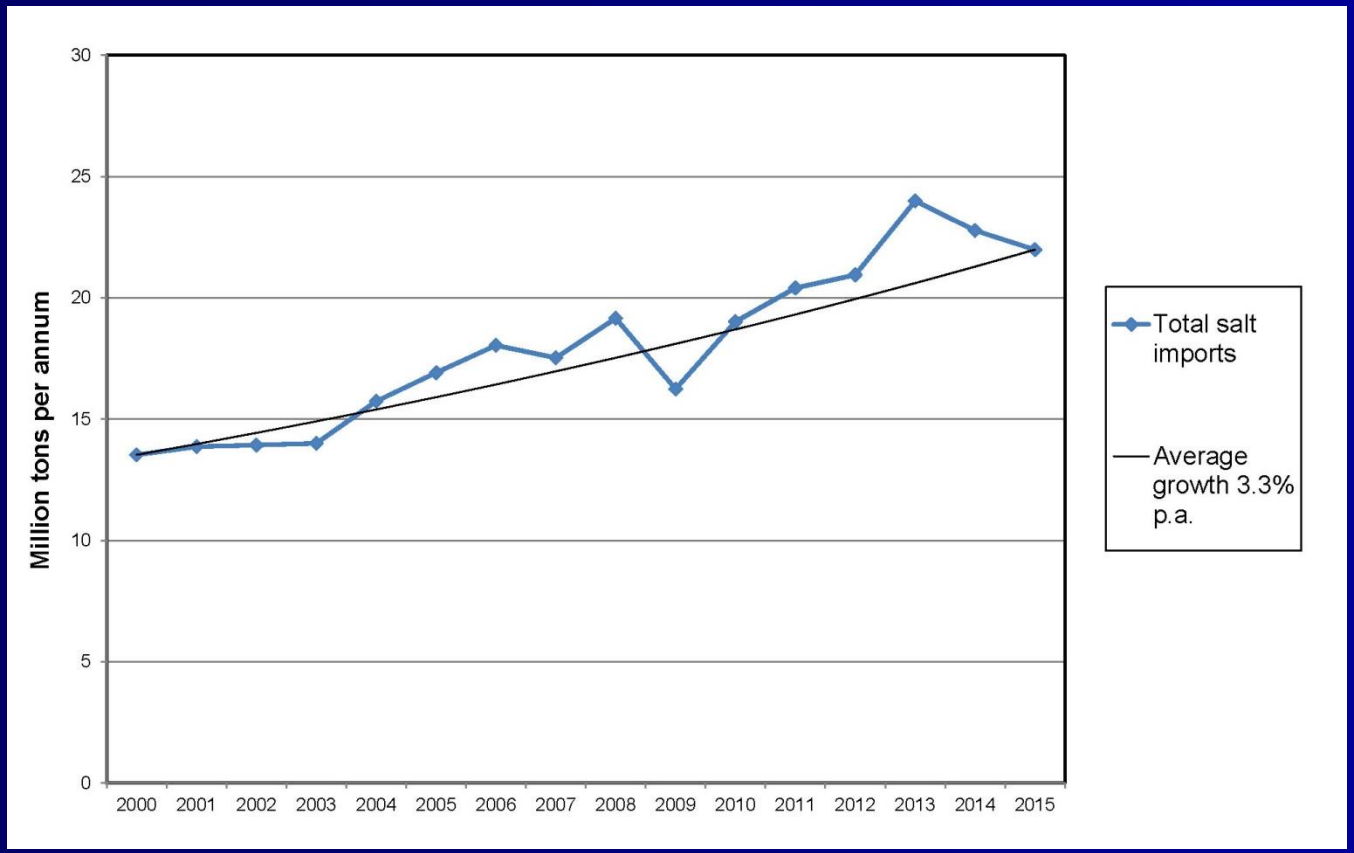
Total Salt Imports in Asia-Pacific



Since 2000, salt imports of 5 largest salt importers in Asia Pacific region have risen by 8.5 million tonnes, equal to 62%, or equal to 3.3% per annum.

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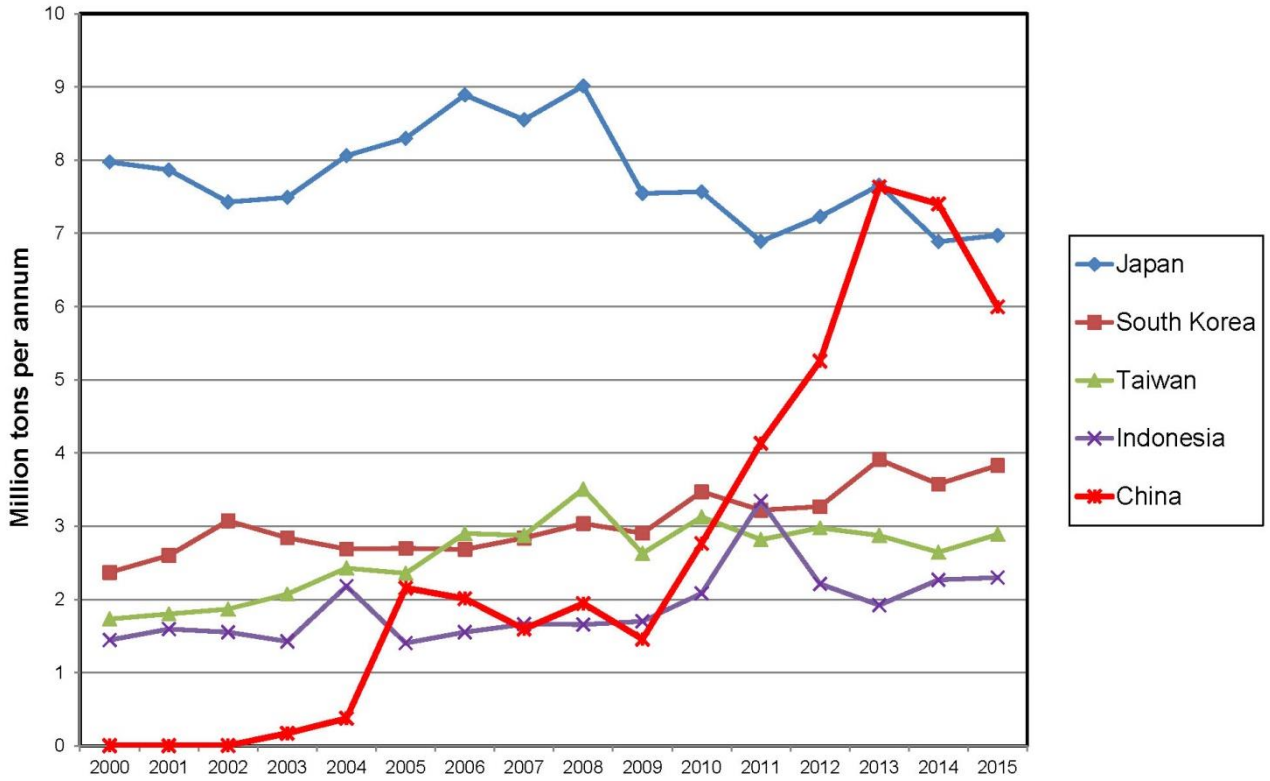
Largest Salt Imports in Asia-Pacific



Salt imports of the five largest salt importers in Asia Pacific region. Since 2000, these countries have increased their salt imports by average 3.3% per annum.

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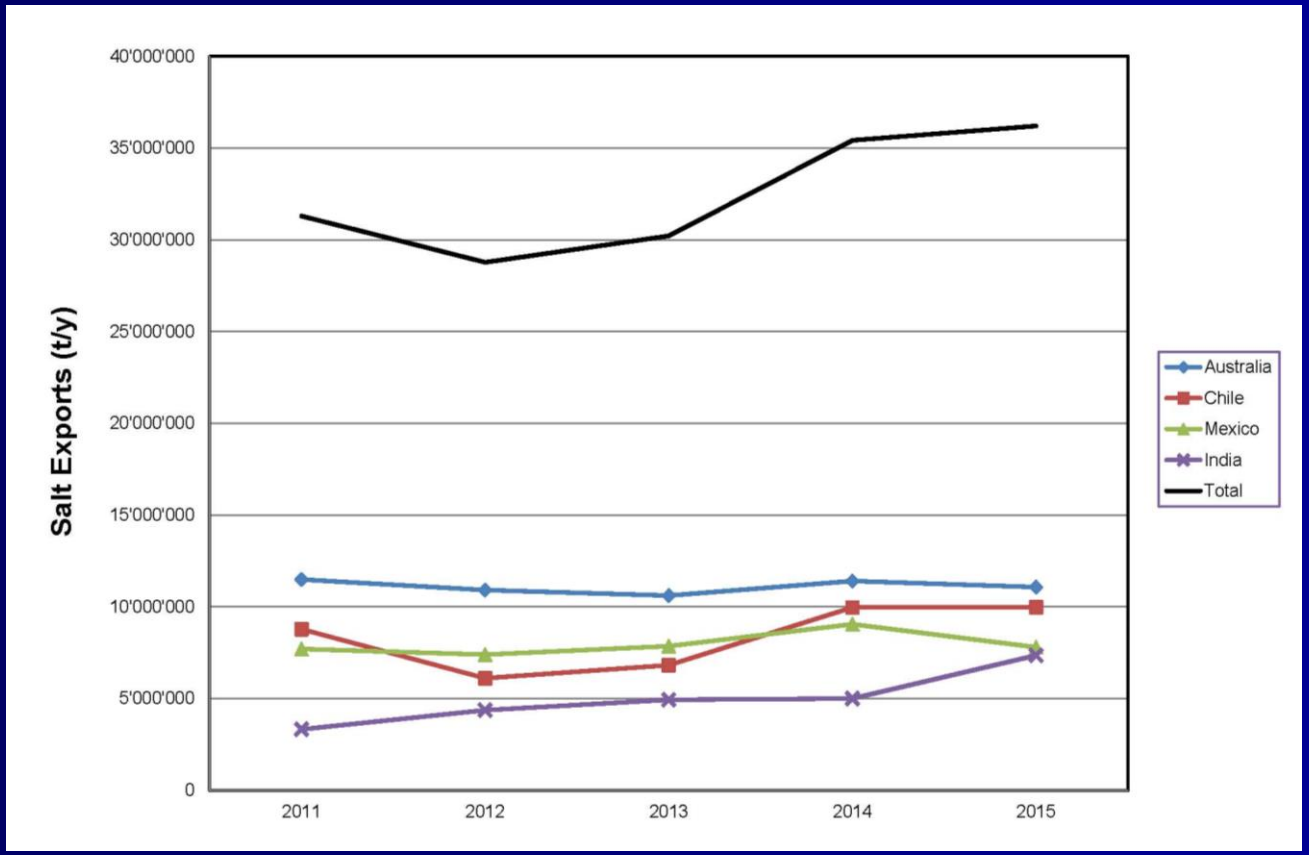
Salt Exports in Asia-Pacific



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Since 2011, salt exports of 4 largest exporters in Asia Pacific region have increased by 5 million tons, or by 16% equal to 3.7% per annum.

However, India increased exports by 4 million tons, or by 120% equal to 22% per annum.

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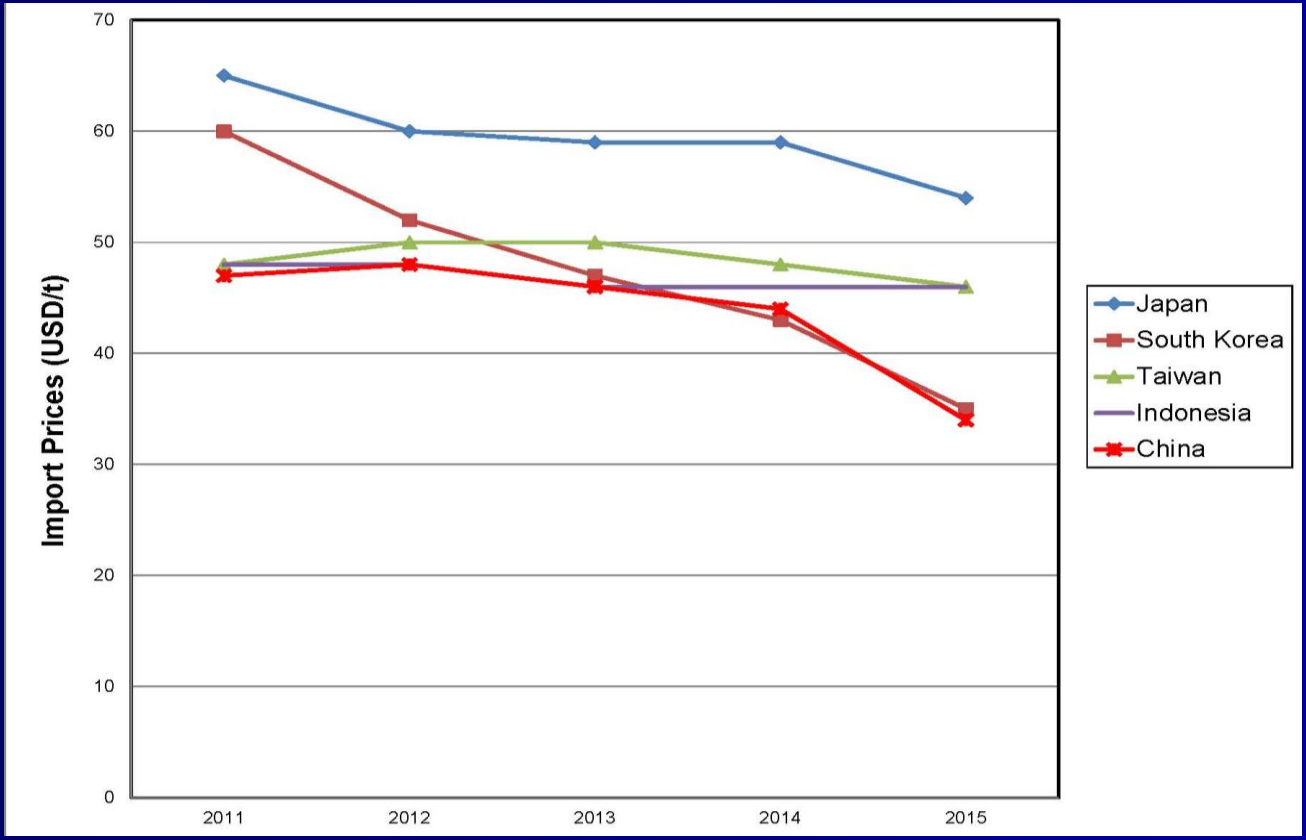
Salt Import Prices in Asia-Pacific



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Since 2011, salt import prices of 5 largest importers in Asia Pacific region have dropped by USD 11 / ton, equal to 20%, or to 5.5% per annum.

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Salt Partners Prospect New Solar Saltfields

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Salt Partners assist their clients to prospect sites where new solar saltfields could be established.

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Salt Partners Supply Salt Harvesters

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Durrant salt harvester type 590-95, one of several machines supplied to Indian solar salt producers.

Salt Partners are proud to have participated in the success story of growing Indian salt exports.

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Salt Partners supply technologies for production of salt according to "Australian standard"

Modern industrial salt upgrading plant in Spain. Capacity 500 t/h solar salt

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Why not turn your salt into gold?

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